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OCTOBER 2019

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OCTOBER 2019

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- [24] **Just Right Lubrication**
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- [41] **Motors without Rare-Earth Magnets: What are the Options?**
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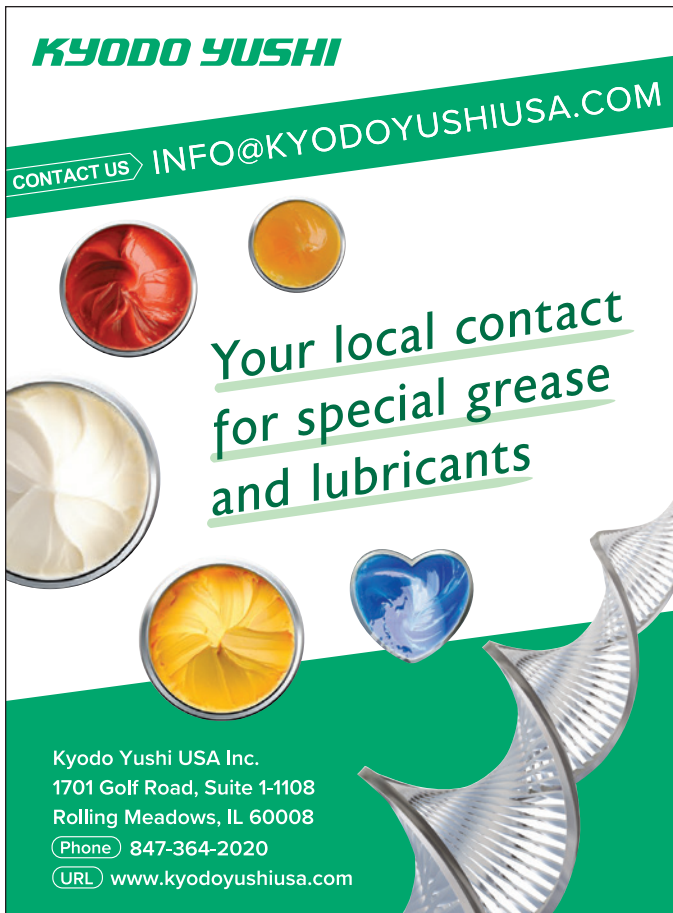
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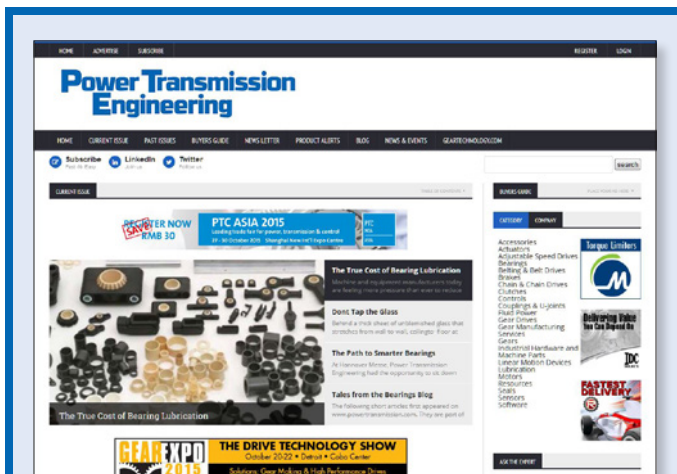
SEARCH

CALENDAR

PTC ASIA 2015
September 14-17 for gears, transmissions & lubricants in Singapore, Singapore

THE TRUE COST OF BEARING LUBRICATION
Don't Tap the Glass
The Path to Smarter Bearings
Tales from the Bearings Blog

GEAR EXPO 2015
THE DRIVE TECHNOLOGY SHOW
October 20-22 • Detroit • Cobo Center
Solutions, Gear Making & High Performance Drives



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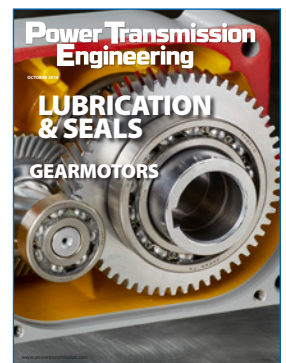
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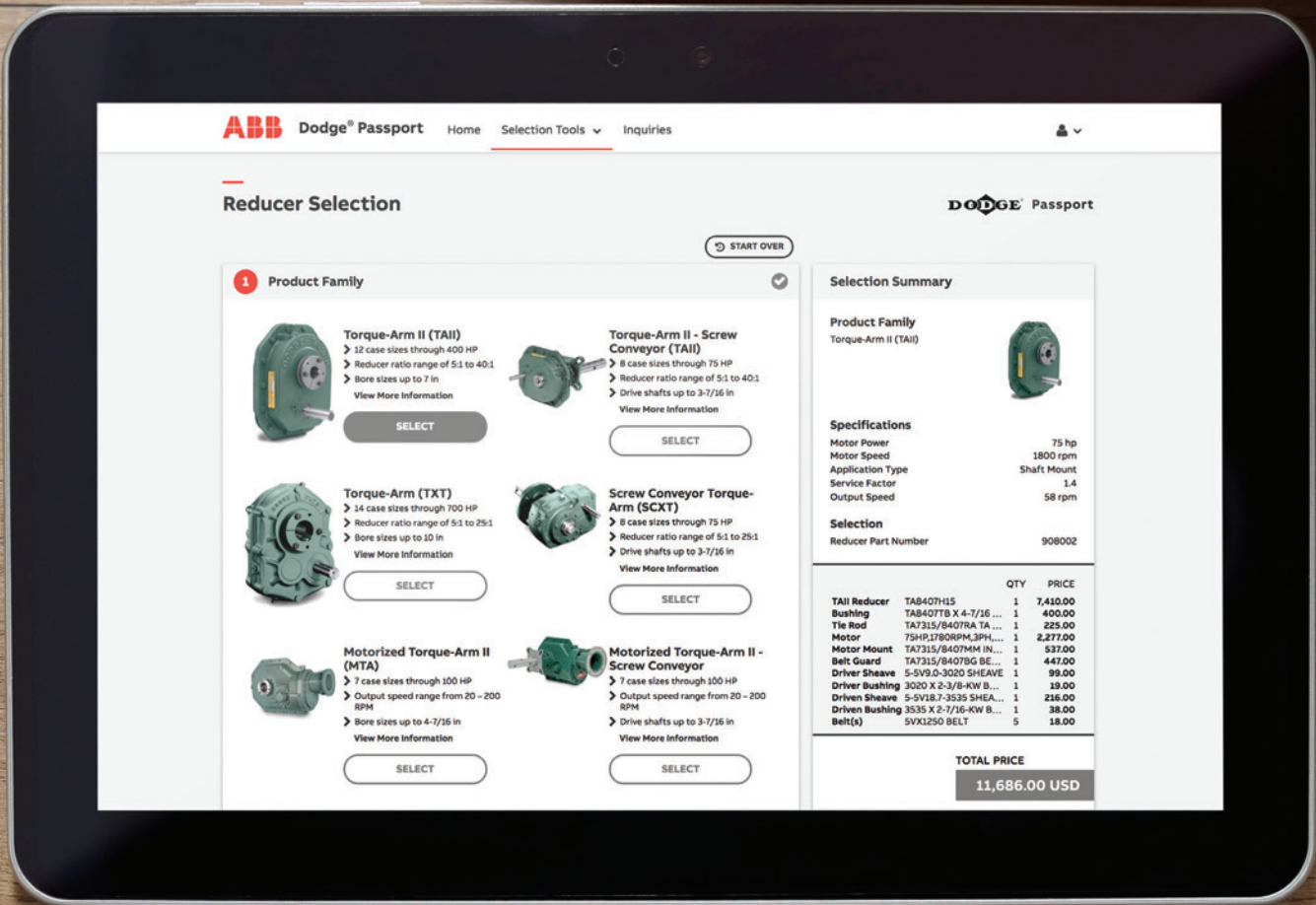
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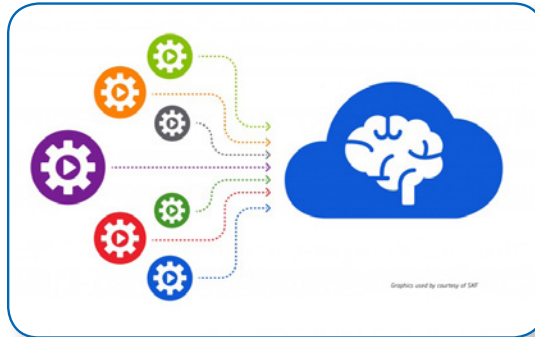


Editor's Choice:

What Does the Future Hold for the Automotive Industry?

Romax's CTO Barry James discusses the effort being placed on studying, discussing and predicting the future of the automotive industry and where investments should be made.

www.powertransmission.com/blog/what-does-the-future-hold-for-the-automotive-industry/



SKF Examines the Power of Data & Machine Learning

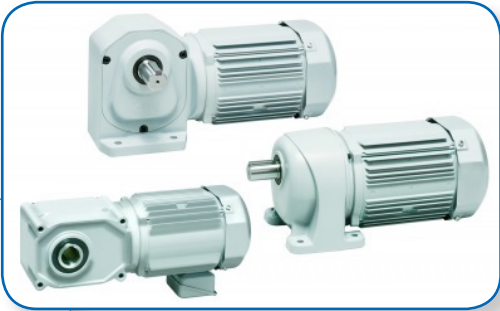
Data is fast becoming one of the most important assets for companies throughout industry. In particular, it holds the key for developing a new generation of machine learning technologies that will have the potential to deliver even higher levels of production and efficiency, while empowering employees to make faster, better informed decisions. Learn more here:

www.powertransmission.com/blog/skf-examines-the-power-of-data-machine-learning/

PTE Videos IRAM Series

I-MAK offers a large range of helical geared motors. Learn more here:

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Brother Gearmotor Warranty

Brother backs quality with performance on their full line of gearmotors and accessories to meet virtually any manufacturing power generation need. Learn more here:

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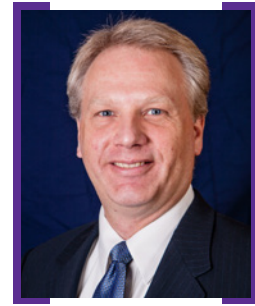


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Core Subjects



Power Transmission Engineering is a unique magazine. Instead of focusing on a specific industry, we focus on specific subject: namely, the mechanical power transmission components that drive many different types of machinery.

So we find ourselves continuously writing about the same things: gears, bearings, motors, gear drives and so on.

But this is a good thing.

It gives us a chance to cover these components from many different angles and explore the various industries they're used in. We believe that an engineer working in the mining industry can learn from our examples in the food and beverage industry, for example. Aerospace engineers can learn from automotive articles, and automotive engineers can learn from construction industry articles. You get the idea. The point is that we're trying to bring you the best examples of articles about mechanical power transmission solutions, no matter where they come from.

This issue we have a focus on lubrication, and we have several articles that should be of interest, no matter your industry. Senior editor Matthew Jaster's article on automatic lubrication systems (p.24) explores how lubrication is advancing into the era of Industry 4.0. The article "6 Critical Grease Characteristics" (p.30) highlights the different functions of bearing grease and gives you ideas about how to determine the optimal blend for your application. And in "High-Performance Plastics," we explore how new materials are advancing the science of seals.

We're also taking a close look at gearmotors this issue (p.18). Contributing Editor Joseph Hazelton talks with several leading manufacturers of gearmotors to explore the ways increasing gearmotor efficiency can save money in your applications, whether you're replacing a whole factory's worth of conveyor gearmotors or redesigning an internal components for an end product like an automated guided vehicle (AGV).

Our motors blogger and frequent contributor, George Holling, helps us understand how advances in electric motor technology are bringing down costs, opening up new applications and freeing the supply chain from reliance on increasingly difficult to source rare-earth elements (p.41).

Finally, we have a pair of technical articles about gears and gear drives for electrified automotive powertrains. The first presents a method to model power losses in a geared transmission (p.44). The second explores the suitability of powder metal gears for high power density applications, with a special focus on how they can be adapted to the NVH and high speed requirements of e-drive applications.

It's a full issue, covering many of our core subjects, and then some. I'm proud to present it to you, and I hope you find these articles interesting and useful. I would appreciate it if you let us know how we're doing. If you have any reaction to any article in this issue, positive or negative, please send an e-mail to wrs@powertransmission.com.

A handwritten signature in black ink that reads "Randy Stott". The signature is written in a cursive, flowing style.

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Timken

OFFERS CORROSION-RESISTANT BEARING TECHNOLOGY

The Timken Company is helping food processors everywhere enhance reliability, improve production and elevate food safety with a specifically engineered product portfolio, which now includes its new corrosion-resistant bearing technology that stands up to the toughest demands of the food and beverage industry.

As population growth and increasing urbanization drive global expansion in food and beverage markets, food processors require reliable solutions to keep their operations running smoothly. Timken Corrosion-Resistant Ball Bearing Housed Units and Corrosion-Resistant Poly-Round Housed Units have been designed and developed specifically with the industry in mind. Featuring hygienic construction and corrosion-resistant materials, both solutions deliver outstanding protection against corrosion in all types of food and beverage production environments and can withstand frequent washdowns for extended operating life under even the toughest conditions.

“Preventing contamination and operating safely are the top priorities of food processing facilities everywhere, but just as important to the bottom line are optimizing production and maximizing uptime,” said Drew Learn, manager, food and beverage markets, The Timken Company. “At Timken, we design bearings with each of these considerations in mind, and we’re continuously looking to grow our portfolio of machine components for every area of the food processing floor.”

Timken corrosion-resistant bearing solutions for the food and beverage market can help operators realize:

- Improved food safety. Meeting stringent food safety legislation, trust Timken to deliver reliable operations with peak performance in critical machines.
- Reduced maintenance. With longer operating life under the toughest food processing conditions, reduce your need for ongoing maintenance checks.
- Decreased unplanned downtime. Avoid expensive shutdowns and maintenance-related downtime by heading off costly changeouts with long-lasting products designed to handle corrosion and harsh chemicals.



Additionally, eliminate downtime from mandatory cleanings or the need for constant re-greasing.

- Increased overall productivity. Maintain optimum uptime despite washdowns and fast throughput with engineering expertise from Timken.

Corrosion-Resistant Ball Bearing Housed Units, coupled with food-grade lubricant, protect against a variety of wet and dry contaminants and are ideal for a multitude of food processing applications, including conveyors, mixers, metal detectors, checkweighers, tumblers, slicers, breaders, peelers and more.

Corrosion-Resistant Poly-Round Housed Units require no lubrication at all, making them ideal for applications where sanitation and contamination are critical concerns, including a variety of conveyor systems, dumper pivots, horizontal mixers, chillers and freezers, and more.

For more information:

The Timken Company
Phone: (317) 613-5643
www.timken.com

Applied Motion Products

CLOSED-LOOP INTEGRATED MOTORS SAVE ON SPACE REQUIREMENTS

Applied Motion Products offers StepSERVO Closed Loop Integrated Motors for closed loop servo control of position, velocity and torque resulting in higher acceleration rates and faster machine cycles in food & beverage applications. Combining a high-torque step motor with an on-board drive, encoder, controller and closed-loop servo software into a single package, the integrated motors save on space, wiring, and cost over conventional systems comprised of separate motor and drive components.

Using encoder feedback, closed loop step motor systems automatically reduce current to the motor when torque is no longer demanded by the load to consume less power than a traditional step motor system. StepSERVO Integrated Motors also operate cooler and more quietly





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Offset Couplings from Zero-Max reduce space requirements for parallel offset shafts in large system applications. These specialized couplings provide machine designers with an important option for reducing overall machine size and footprint.

Compact in design, Schmidt Offset Couplings transmit constant angular velocity and torque in a wide range of parallel shaft misalignments. Handling high amounts of parallel offset up to 9 inches, they are available with torque capacities up to 459,000 in.-lbs.

Schmidt Offset Couplings can be mounted to shaft hubs or directly to existing machine flanges. They are available for shaft displacements of 0.156 inches to 17.29 inches and torque capacities from 55 to 459,000 inch-pounds. Many design configurations are available including specials.



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than open loop step motors by drawing just enough current to control the load.

The ability to execute stored programs created with Applied Motion's Q Programming language enables users to apply complicated logic and motion sequences to solve their motion control challenges. For example, in a product labeling application in a food and beverage plant, a product sensor can be tied to one of the motor's digital inputs, triggering a WI (Wait Input) command when the product nears the

labeling position. To prevent wrinkling or tearing, the label must be applied at the same speed the product is traveling on the conveyor. To accomplish this, the motor measures the conveyor speed from a master encoder whose A/B quadrature signals feed into the motor's X1 and X2 digital inputs. The FE (Follow Encoder) command automatically ratios the label speed to the master encoder frequency while monitoring the label sensor to position the label at exactly the right location on the

product. The powerful math capability built into the Q Programming language provides additional customization and control options.

Applied Motion offers its StepSERVO Integrated Motors in IP65 rated versions for wet and dusty environments. Units are available with industrial network communications including CANopen, EtherNet/IP, Modbus RTU and TCP, as well as support for third-party PLCs and HMIs.

For more information:

Applied Motion Products
Phone: (800) 525-1609
www.applied-motion.com

LM76

RELEASES CERAMIC RADIAL BALL BEARINGS

LM76 has announced the release of their new line of Radial Ball Bearings featuring ZrO₂ (Zirconia) Ceramic balls. To Complement LM76's broad range of Linear Bearings that are FDA/USDA/3A Dairy compliant, as well as linear bearings for extreme environments; they have added Deep Groove bearings which accommodate radial and axial loads, Angular Contact bearings for simultaneously handling radial and axial loads, Spherical Bearings which are self-aligning, and Thrust Bearings for high axial loads. Each of the four types of metric bearings are available in a wide range sizes.

The advantages of ZrO₂ ceramic balls are: FDA/USDA/3A Dairy/Caustic washdown compliant, lighter than steel balls and can be used at extreme rpms, they withstand higher loads without spalling, have a lower coefficient of friction, are inert to chemicals, have no magnetic signature, and are non-conductive.

With the addition of these radial bearings with ZrO₂ Ceramic balls LM76



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Ogura

OFFERS NEW LINE OF MICRO BRAKES

Ogura has developed a new line of micro brakes for servo motor applications. These small brakes and motors are primarily used in robotics and medical equipment. Ogura micro holding brakes come in both square and round designs.

The newest round design is 10 mm in diameter, length is as short as 9 mm. Micro brakes can weigh 20 g or



less allowing for reduced inertia on fast moving robotic arm applications. Ogura brake coil designs allow for over-excitation, contributing to small size and low energy consumption, especially useful on battery powered equipment and/or mobile robots. All brakes are designed to reliably handle the equivalent torque load of the motor that it pairs with dimensionally.

Standard coil voltage is 24, but other design voltages are possible. Also, brakes can come with bare lead wires or can come with customer supplied electrical connectors.

For more information:

Ogura Industrial Corp.
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Portescap

RELEASES NEW LINE OF MOTORS FOR SURGICAL APPLICATIONS

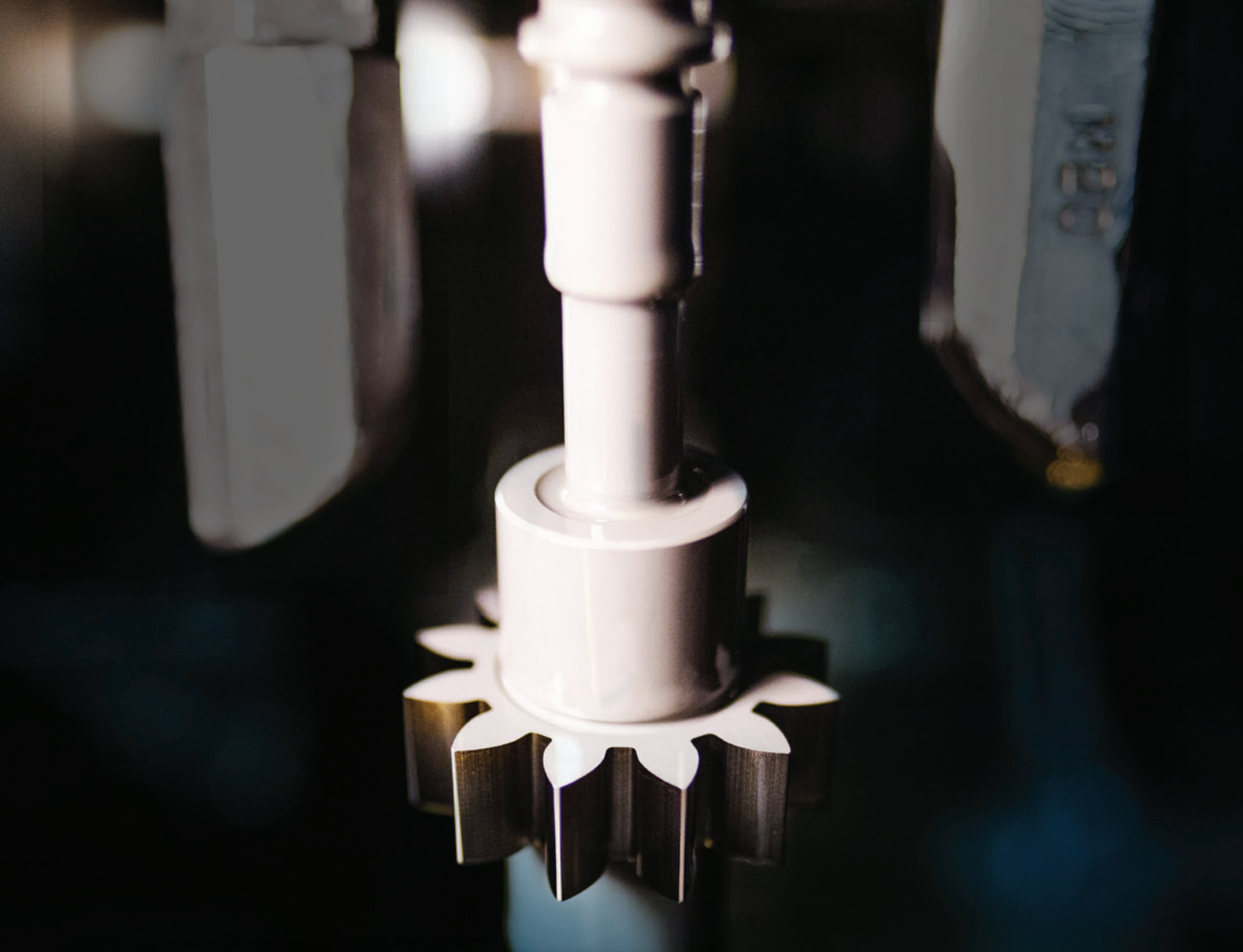
Portescap is pleased to announce the release of a new line of standard prototype motors for surgical applications. These 15 motors represent Portescap’s new SM series of surgical motors designed to meet the demanding requirements for surgical devices at a more cost-effective price point. These motors leverage Portescap’s market leading sterilizable design approach and surgical application expertise to provide a more affordable and consistently reliable solution for surgical device makers. These motors have been optimized for Powered Staplers, Large and Small Bone Orthopedic Tools, Arthroscopic Shavers, ENT Microdebriders, and High-Speed Neuro Drill applications. They are also well-suited for traditional surgical tools, as well as for robotically assisted surgical devices and can be paired with a Port-

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97Krpm, and torques up to 17.5 oz-in. They are lightweight with low noise and vibration to maximize tactile response and surgeon control in the most delicate of surgeries.

Standard prototypes are available within two weeks, enabling Portescap's partners to begin testing quickly and shorten their time to market. Portescap's R&D engineers are well versed in medical device integration and are eager to collaborate—for partners needing custom solutions, Portescap can optimize a design to meet the exact requirements of the application.

For more information:

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Ruland Manufacturing

QUICK CLAMPING SHAFT COLLARS UTILIZED FOR GUIDING, SPACING, MOUNTING AND ALIGNMENT

Ruland now supplies quick clamping shaft collars with clamping levers. These adjustable levers mate a Ruland metric and international series inch shaft collar to a specially designed clamping lever, creating a shaft collar that requires no tools to install, remove, or reposition.

Once the lever is installed, users can simply turn it until they meet their desired torque. For fine adjustments, the lever must be lifted and twisted 40 degrees to lock it in a new position. This feature has the added benefit of allowing the lever to be used in space constrained applications where 360-degree motion is not possible. Quick clamping shaft collars with clamping lever are significantly faster to adjust than collars with standard hardware, making them ideally suited for

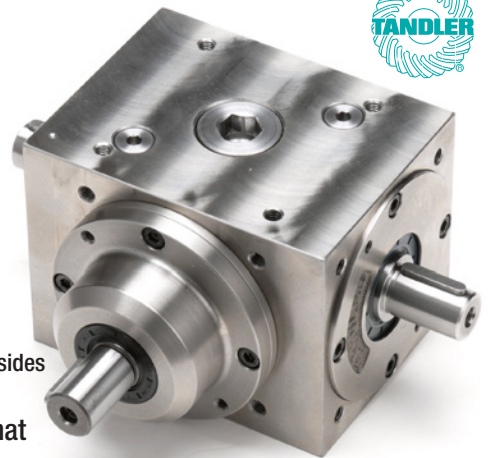


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packaging, printing and other applications where frequent set-up changes and adjustments are needed.

Quick clamping shaft collars with clamping lever can be used for guiding, spacing, stopping, mounting and component alignment. They have reduced holding power when compared to standard shaft collars as it is not possible to precisely control seating torque. Designers benefit from the tightly controlled face to bore perpendicularity of Ruland shaft collars (TIR \leq 0.05 mm or 0.002 inch) which is critical when they are used as a load bearing face or for component alignment. Ruland identifies this work surface with one or two circular grooves on the face of the shaft collar to assist in installation.

Ruland manufactures shaft collars from high-strength 2024 aluminum,

1215 lead-free steel with a proprietary black oxide finish, and 303 and 316 stainless steel. Quick clamping shaft collars with clamping levers are available in sizes ranging from 11 mm to 40 mm or $\frac{7}{16}$ inch to 1½ inches. Shaft collars are manufactured in Ruland's Marlborough, Massachusetts factory under strict controls using proprietary processes. Levers are sourced from JW Winco and have a stainless-steel threaded stud (M4-M6) that is used to replace standard collar hardware. All components in these shaft collars are RoHS3 and REACH compliant.

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Saving Money with High-Efficiency Gearmotors

Joseph L. Hazelton, Contributing Editor

Standing in a factory or a warehouse, you're bound to notice machinery, whether it's a conveyor system that winds across the floor or large fans that hang from the ceiling. You may even notice automated guided vehicles or autonomous mobile robots carrying parts, driving themselves from one section of the building to another.

These machines — conveyors, fans, AGVs, AMRs — are good candidates for using high-efficiency gearmotors, especially if they're expected to run for long stretches at a time. If they aren't using high-efficiency gearmotors, then they may be costing more money than they should.

Machines' gearmotors can have a sizable effect on an energy bill. According to Christopher Moskaites, depending on the facility, its gearmotors may account for up to 50 percent of its energy bill.

Moskaites is product manager — electro-mechanical solutions for Lenze Americas. Located in Uxbridge, MA, Lenze makes gearmotors for the logistics and automation industries, among others.

Given their effect on energy bills, the long-running machines get the most attention from companies that want to save money. "They really focus on the ones that are more continuous duty," Moskaites says.

To save money with high-efficiency gearmotors, an end user has to consider many things, big and small, from whether its application runs long enough to benefit from high-efficiency gearmotors to how many gear stages are needed in a gearmotor's gearbox.

Long Stretches of Time

High-efficiency gearmotors reduce energy costs when the gearmotors are used in machines that operate continuously or near continuously.

Now, it's easy to figure out which machines operate continuously. They operate 24/7/365.

But, which machines operate near continuously? What does "near continuously" mean? That is, how many hours does a machine have to run for it to operate "near continuously"? Does it have to run 20 hours? Fifteen hours? How many hours are enough?

Several, according to Michael DeMeo.

He's national electronics sales engineer for SEW-Eurodrive Inc. Located in Lyman, SC, SEW-Eurodrive makes gearmotors for a number of industries, including the airport and parcel industries.

DeMeo says that after a system is up and running continuously for several hours, energy savings can be obtained, especially if the system is operating at peak load. He adds that in a 24/7 operation, a system may operate continuously for

only five to six hours during each eight-hour shift and still show energy savings.

Depending on the application and its load, though, several hours may not be enough, but to operate "near continuously," a machine doesn't have to be running for 18, 19, 20 hours.

Now, AGVs and AMRs, because they use batteries, they need high-efficiency gearmotors in order to run as long as possible,

"If you're running on a battery and you're not efficient, your battery is not going to last very long, and you're not going to get a lot of work done in the warehouse," says Matthew Roberson.

Roberson is vice president of Brother Gearmotor, a division of Brother International Corp. Located in Bridgewater, NJ, Brother Gearmotor serves the food and beverage industry, the packaging industry, and others.

Naturally, AGVs and AMRs need to recharge their batteries from time to time. But, the more efficient their gearmotors, the less often they need to — and the more work they get done between recharges.

Gauging Efficiency

But, how to know whether the gearmotors in an application are high efficiency? And if they aren't, how to know whether high-efficiency gearmotors would reduce energy bills?

One way to find out both things: Bring in a gearmotor manufacturer.

A number of them are willing to look at the gearmotors in an application, measure the energy consumption of the application, decide whether high-efficiency gearmotors could be installed, and estimate how much less energy would be consumed if they were installed.

Now, gearmotor manufacturers will measure an application's energy consumption rather than its energy efficiency because efficiency can be tricky to calculate. Also, by looking at energy consumption, they avoid the possibility of *system* efficiency being mistaken for *gearmotor* efficiency.

Both practices are explained by Tom Koren, director of engineering for Nord Gear Corp., Waunakee, WI. Nord makes gearmotors for a number of industries, including the airport and steel industries.

What makes efficiency tricky to calculate is: A gearmotor may be operating normally, no problems, but what about the rest of the application, say a conveyor system? What if there's a problem elsewhere in the system, a problem that makes the gearmotor seem less efficient?

"Was there a worn bearing binding up on the conveyor during our test?" Koren says. "We don't know."

Because there's always the possibility of a problem elsewhere, a gearmotor manufacturer may decide it best not to

suggest that a competitor's gearmotor is less efficient when it may only *appear* to be less efficient.

As for why measure energy consumption: "You don't tie dollars signs to efficiency," Koren says. "Efficiency is really what you're improving, but it's not what you're paying for. You're paying for energy."

So, gearmotor manufacturers would report on the number of kilowatt-hours consumed by a system, not on the percentage of a gearmotor's energy efficiency.

Measuring Energy Consumption

Now, a system's energy consumption can be measured in several ways: theoretically, actually, and with a one-off replacement.

For example, a theoretical study would include a detailed list of a system's conveyors, their expected loads, and their expected energy consumption. In an actual study, the system would be equipped with devices for recording the actual energy consumption.

A one-off replacement study would involve replacing one gearmotor in a system. In this case, to start off, a gearmotor would be selected and a power meter attached to it to record energy consumption. The gearmotor may be a system's worst-case scenario, the gearmotor that uses the most energy because, for example, it powers a conveyor with an incline.

After some time, the power meter would be detached, the gearmotor removed, a new gearmotor installed, the meter reattached, and energy consumption recorded again. In the end, energy consumption with the old gearmotor would be compared to energy consumption with the new one.

However, both actual study and one-off replacement may take considerable time, depending on the application.

To illustrate, Koren estimates the time for an actual study of a conveyor system at an airport: three months. "We like to get two to four weeks of data per conveyor type or conveyor setup," he says. "There's inclines, there's declines, there's merges, there's transfer conveyors." After the data is gathered, the rest of the time is spent analyzing it and creating a proposal for new gearmotors. Naturally, if the conveyor system is more complicated, the study would likely require more time.

Besides being complex, though, a system would take time to study if it handles variable loads. The airport conveyor system is a good example. "You can't go in for a couple days because you need to look at the average bag traffic," Koren says. "The weekend travel is much different than the week-day travel. And a month with holidays, as in the Fourth of July, there's less business travelers."

Koren adds, though, that a system with a consistent load would likely require fewer days for gathering data: "You can go in and snap a smaller picture."

Like an actual study, a one-off replacement study could take months.

According to DeMeo, a power meter could be left on a gearmotor for four weeks.

To Save Money Takes Planning

Now, with a study taking months, it can be easy to lose sight of the real goal: saving money with high-efficiency gearmotors.

If the goal is kept in sight, though, then knowing how long a study takes, can be a help. An end user can plan for a lengthy study. It can estimate total time for the whole process: time for the study, time to review and decide on the proposal, time to install the new, high-efficiency gearmotors.

Knowing the total time is especially important if the money for improving a system is available for a limited time, like until year-end. That way, an end user can contact gearmotor manufacturers long, long before year-end, avoiding a time crunch.

Some end users, though, may not need a study to be sure of lowering their energy bills. "There is real cost savings," Koren says, "and some people realize that and just spend the money upfront, but majority wants the studies."

Starting with the Motor

Now, doing a study may be complicated and time consuming, but finding a high-efficiency gearmotor starts simply with the motor, with one that generates enough starting torque and continuous torque for an application, whether a small AGV or a large conveyor system.

The needed torques may be found in different types of motors, from a standard AC induction motor to a permanent magnet motor (PMM). If a motor type isn't efficient enough, it may be possible to modify it so it can be energy efficient. For example, AC induction motors can be made with more copper windings.

However, depending on the application, it may be necessary to change to a different motor type in order to have high-efficiency gearmotors.

For example, a different type may be needed if the application handles variable loads. In that case, the system's motors



An application's load and speed, whether they're constant or variable, are considerations when trying to lower energy costs through high-efficiency gearmotors. (Photo courtesy of Nord Gear Corp.)



The larger an application, the more gearmotors it has, and the more its energy bills may be reduced through high-efficiency gearmotors. (Photo courtesy of Nord Gear Corp.)

may be slowed down when it's handling a lighter load.

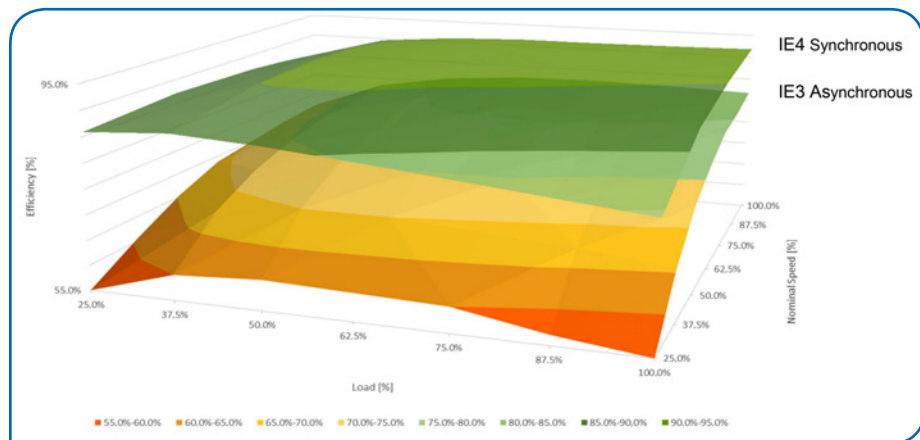
However, high efficiency at full load may not be high efficiency at partial load. Koren explains: "You might have a 90 percent efficient motor, but at half load, it might only be 70 percent efficient."

Koren adds an example of where high-efficiency gearmotors could be running inefficiently at partial load: a distribution warehouse in the retail industry. In that case, the warehouse would've sized its conveyor system to handle a peak load that occurs during part of a year, like the holiday season. But, what about the rest of the year?

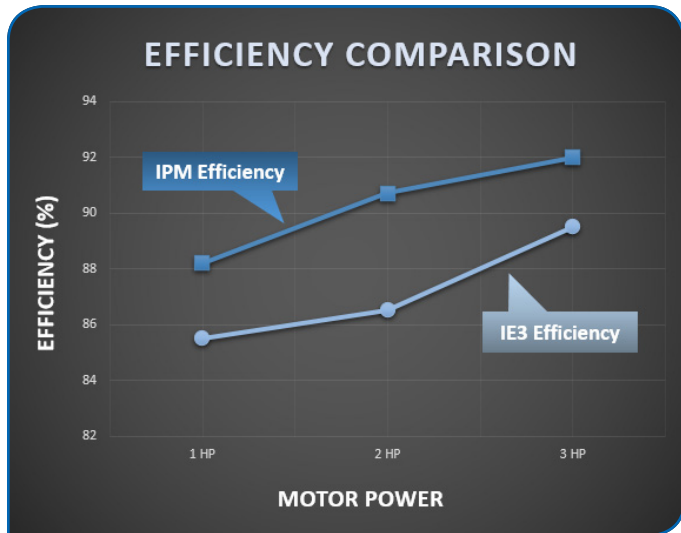
"In July, that conveyor might be at 25 percent load," Koren says. "With standard motor technologies, that is a very inefficient system. With permanent magnet motor technologies, it's a very efficient system."

Koren explains that the difference is the PMM's efficiency curve: "It's a very flat efficiency curve." So, a highly efficient motor at 100 percent load would still be highly efficient at 50 percent load. "A permanent magnet motor does not lose that efficiency at partial load or partial speed," Koren says.

PMMs are more expensive, but the extra expense may be offset by extra savings from a system that's highly efficient



If an application, such as a conveyor system, handles variable loads and speeds, permanent magnet motors may be the option for high-efficiency gearmotors. PMMs may be the option because of their relatively flat efficiency curve at partial load and partial speed. (Photo courtesy of Nord Gear Corp.)



A gearmotor's high efficiency depends in part on the motor's efficiency. An application's best efficiency may be obtained in part through a particular type of motor, like a motor with an internal permanent magnet. (Photo courtesy of Brother Gearmotor)

whether its load is heavy or light.

To figure the savings, an end user would need to look at total cost of ownership with its current gearmotors and estimated total cost of ownership with PMMs. Then, it could see when the extra savings would equal the extra expense, could see the breakeven point. After that point, the extra savings that were paying for the more expensive motors, could become extra savings spent elsewhere or banked.

To take advantage of its efficiency curve, a PMM would need to have a motor controller, also called an inverter. In applications with variable loads, the controllers could also increase the energy efficiency of the motors by allowing them to index and turn themselves on and off.



If an application's load and speed are variable, then its gearmotors may need to be topped with motor controllers so the gearmotors, and the application, are as energy efficient as possible. (Photo courtesy of SEW-Eurodrive Inc.)

“Does the conveyor need to run constantly, waiting for a box or a suitcase?” Koren says. “Or can it wait for a suitcase to be fed to it and then turn on and turn back off?”

This efficiency could be lost, though, if a motor is indexing excessively. “If you’re indexing too often, it does take extra energy to accelerate and a waste of energy to decelerate,” Koren says. “It might make more sense to just leave it running.”

Excessive indexing—that is, reduced energy efficiency—can be avoided through a programmable logic controller. A PLC can operate its motor in the most energy-efficient way. For example, once a system’s most efficient indexing rate is figured, the PLC can be programmed to include the minimum load for continuous running. Koren describes the communication between the motor controller and the motor: “If my demand gets below this, then slow down the speed or turn off altogether.”

Rightsizing the Motor

While figuring out a system’s motors, an end user faces another challenge: not oversizing.

According to Moskaites, historically, end users have tended not to use properly sized motors; they’ve tended to oversize, which wastes a lot of energy. “We find that a lot,” he says. “That’s a good way to conserve energy, is just to make sure you’re using the proper motor.”

An oversized motor may be part of a system because somebody chose the motor years ago and since then, whenever it needed to be replaced, no one thought to try another size. Moskaites knows that situation: “Somebody just says, ‘I’ve always used a five-horsepower motor, I’ll just keep using that.’”

Another reason for an oversized motor: An end user wants safety, perhaps too much safety. If too much: “that safety that you’re building into the system, may cost you thousands of dollars a year,” Koren says.

Today, however, end users appear to be rightsizing their motors more often than they used to. That’s what Moskaites has observed. When he walks through facilities, he does see oversized motors in many conveyor systems, but he adds: “It’s starting to happen less and less.”

Or, an end user may oversize because it doesn’t want to run a fan to cool the motor. A system may need only one-quarter horsepower to operate, but the end user buys a five-horsepower gearmotor so it won’t overheat. The end user saves energy by not running a fan, but it now has a five-horsepower gearmotor doing one-quarter horsepower of work.

“You lose your efficiency,” DeMeo says.

One more reason that a motor may be oversized: An end user may not know how much power is actually needed by its system.

To figure out the needed power, DeMeo uses a conveyor system as an example. Begin with the system’s starting torque, but assume the system will sometimes need to be started when it’s fully loaded, when the starting torque will need to be greatest.

Say the starting torque needs to be 200-plus percent, so a two-horsepower motor with a five-horsepower frequency inverter is installed. The conveyor system now has its needed starting torque.

However, once the system is started, it may need only one horsepower to keep running. “So, I’m wasting all this money,” DeMeo says, “all this sizing, all these bigger sizes, just to get by with that starting torque.”

Moreover, he points out: “I still need a certain amount of energy to keep that two-horsepower motor energized even though I only require one horsepower.”

The starting torque of four-plus horsepower, though, can be had through a one-horsepower permanent magnet motor.

“For the same one horsepower, you gain the starting torque without increasing the size of the motor,” DeMeo says. “So, after we get our two, three hundred percent starting torque, then I’m still just a one-horsepower unit, and I’m not wasting any energy trying to keep my two-horsepower motor energized.”

“That’s basically the gain of a permanent magnet motor,” he adds. “That leads to the efficiency.”

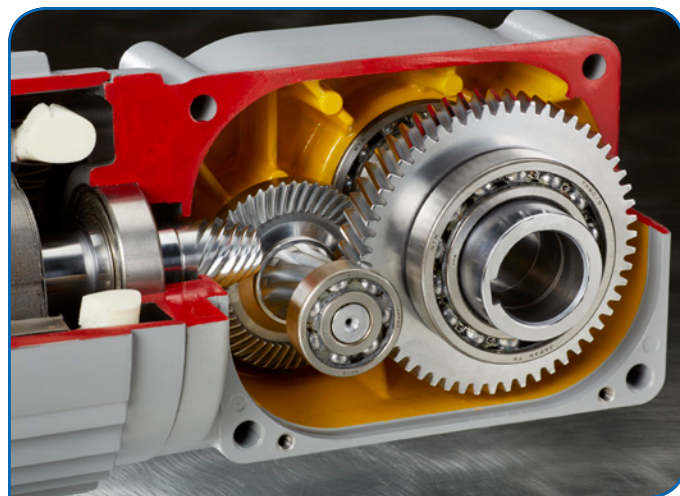
The Gears: Type, Ratio, and Stages

“A lot of people focus on the motors. And that’s good; you should,” Roberson says. However, he adds: “Sometimes, it doesn’t make sense to put a high-efficiency motor on a less-efficient gear train.”

The efficiency of the gears depends on the type of gears. There may be times when gear type is limited by the application. When it isn’t limited, though, the most efficient gears should be selected. As examples, bevel gears and helical gears are more efficient than worm gears.

A gear set’s efficiency also depends on its gear ratio. The higher the ratio, the more efficient the set. The ratio indicates efficiency because it indicates how quickly the gears are changing the speed of the motor’s power. The faster the change, the more efficient the gear set.

Also, higher gear ratios can contribute to a gearbox’s efficiency by minimizing the number of gear stages. Each stage consists of additional components that receive the motor’s power, transmit it, and subtract from it. So, the fewer stages, the fewer components, the fewer subtractions, the more



In a gearmotor, the gear set may consist of more than two gears, more than a driving gear and a driven gear. If the number of gears is minimized, the gearmotor’s energy efficiency may be best kept at a high level because less energy is lost as friction between the gears. (Photo courtesy of Brother Gearmotor)

efficient the gearbox. “You have less shafts, less bearings, less seals, less gears in contact, less churning losses in the gearbox,” Koren says.

Integrating Gearbox and Motor

Depending on the application, the number of components may also be reduced by integrating the gearbox and motor. The resulting gearmotor may be preferable because: “When you make a compact, integral system — gearbox, motor, all in one package — you eliminate certain components, increasing the overall energy efficiency,” Koren says.

To illustrate, he mentions an older conveyor system in which the motors were connected by clutches to their gearboxes. The system’s owner, an airline, was thinking about replacing the drives, more than 800, with new ones in an effort to use less energy, to save money.

After the system’s energy consumption was studied, the motors, clutches, and gearboxes were replaced with gearmotors and motor controllers. Instead of clutches being engaged and disengaged, motors were turned on and off. The system’s energy consumption was studied again.

The result: “It was significant energy savings,” Koren says.

Outside the Gearmotor

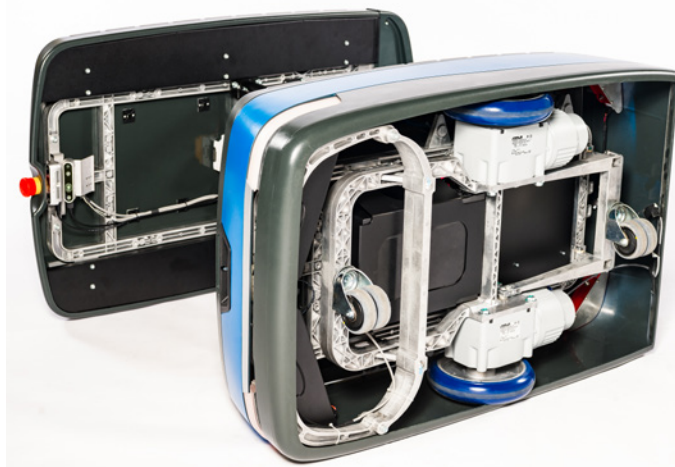
Getting rid of components may be possible outside the gearmotor, too.

Roberson explains that AGV and AMR manufacturers generally prefer their gearmotors be right-angle gearmotors. That way, each gearmotor can be connected to its wheel assembly by a hollow shaft alone, no other components.

“What we’re finding in the AGVs and AMRs is they’re taking their wheel assembly and they’re plugging it in — basically — to the gearmotor,” Roberson says.

If it weren’t a right-angle gearmotor, if it had a different configuration, the connection might require additional components, like a belt or a chain. “Which is really just another system of energy loss,” Roberson says.

He adds that a right-angle gearmotor is a standard request



Depending on the application, a gearmotor’s mounting configuration may keep energy losses to a minimum by keeping to a minimum the number of components between the gearmotor and its energy’s final destination, such as the blue wheels on an AGV. (Photo courtesy of Brother Gearmotor)

from AGV and AMR manufacturers. “You can see that trend out there,” he says. “That compact design, ability to have a plug-in wheel, and not other components within the drivetrain that would lose energy.”

Consequently, when it comes to saving money by using high-efficiency gearmotors, it’s like Koren says: “It’s more than just the energy efficiency of motors. It’s proper sizing and selection of all the mechanical components.” **PTE**

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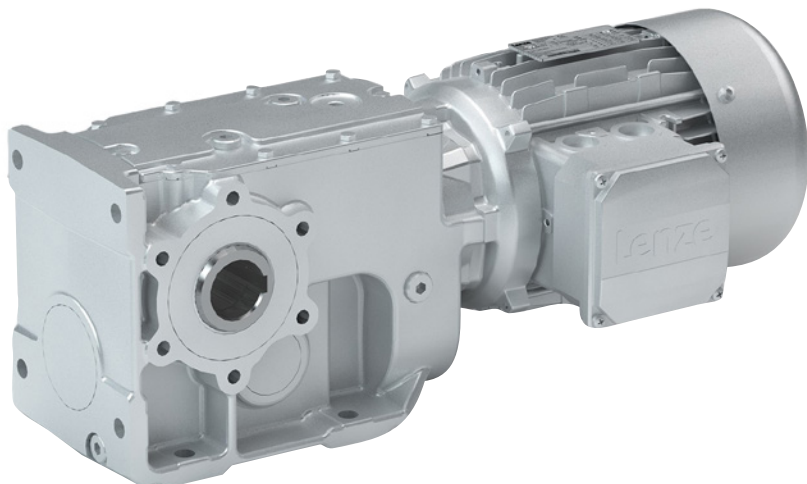
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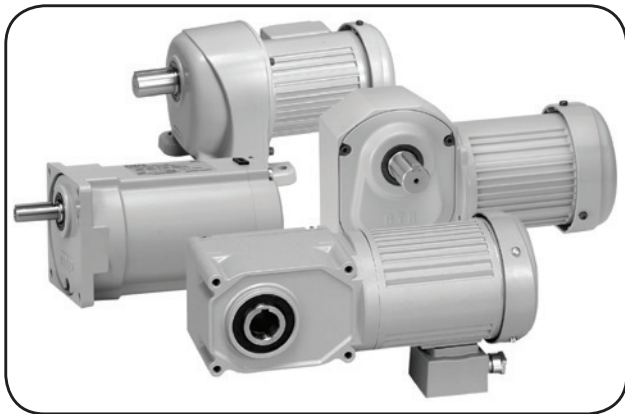


A gearmotor’s efficiency may be best kept at a high level when its energy passes through as few components as possible. Depending on the application, components may be kept to a minimum in part through the gearbox’s configuration, such as inline or right angle. (Photo courtesy of Lenze Americas)

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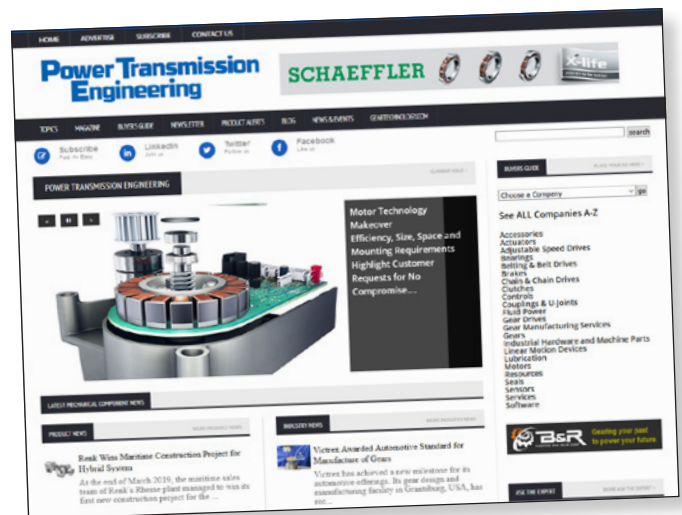
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Just Right Lubrication

Automatic Lubrication Systems are Getting Smarter, Easier to Use and Pushing Condition Monitoring into the Future

Matthew Jaster, Senior Editor

It's all about performance, reliability and service life when it comes to bearings. And in order to optimize these components, proper lubrication is essential. Bearings can be manually or automatically lubricated. However, science and engineering has made quite the technological advances to suggest automatic lubrication is worth considering in 2019. *PTE* spoke with representatives from Schaeffler and SKF on the merits of automated lubrication systems.

Solving Today's Lubrication Challenges

The greatest challenges in bearing lubrication vary with each individual application. There are several key concerns that need to be addressed in general, however, and one of the greatest challenges is making sure the right personnel is in place to do the job.

"Finding qualified people who know how to properly lubricate bearings is always a challenge—especially now when the labor pool is so small. Safety is also a huge concern. Bearing locations can require ladders and lifts in dangerous environments, which puts lubrication technicians in positions that could lead to accidents or injuries," said Robert Phillips, director of sales, ALS North America, SKF.

Phillips said another challenge is ensuring the applied grease is evenly distributed throughout the bearing or lubrication point. The best way to make this happen is to lubricate while the machine is running. This method also eliminates the need for lock-out/tag-out procedures that require machine downtime to apply lubrication.

"Number one is the upfront costs, not just for the equipment but also for training/education, installation, implementation and commissioning," said David French, associate product manager, Industry 4.0—Service



SKF has both single-point and multipoint automatic lubricators that can be either gas-driven or electro-mechanical and range from one to 1,000 points.

Solutions at Schaeffler Group USA Inc. “Companies can choose to research topics themselves or hire an external firm to consult. A benefit of partnering with an external firm is the ‘multiplier effect’ that results from speeding up the learning curve and providing recommendations that can reduce time to implementation.”

The number two challenge for French involves identifying and correcting the root cause of lubrication issues such as over-lubrication, lubricant starvation, improper lubricant delivery intervals, lubricant cross-contamination, etc.

“In addition, most maintenance departments are responsible for a large number of lubrication points that can run into the thousands, and there are always competing priorities. This is where having a structured lubrication program serviced by automatic lubricators can allow companies to reallocate valuable maintenance resources where they’re needed most—without sacrificing equipment integrity,” French added.

The Benefits of Automated Lubrication Systems

French said that bearing damage is a leading cause of equipment failure, and an astonishingly high 55-60% of bearing failures are lubrication-related (e.g., over-lubrication, lubricant starvation, improper lubricant delivery intervals, lubricant cross-contamination, etc.). Automated lubrication systems are a proven way to greatly reduce these common failure modes, in addition to adding significant value by extending bearing life.

“For example, let’s say you currently lubricate your bearings using a grease gun. A bearing in operation can have a lubricant film as thin as 1µm. (To put that into perspective, the average human hair is 75µm thick.) Typically, the smallest dirt particle visible to the human eye is 29µm, which means that even if your lubrication Zerk fitting or grease gun appears clean, manual lubrication could be introducing contaminants 29 times larger than the operating film thickness! Over time, this can lead to premature bearing failure. Connecting an automatic lubrication

system directly into the lubrication port eliminates this risk and helps extend bearing life,” French said.

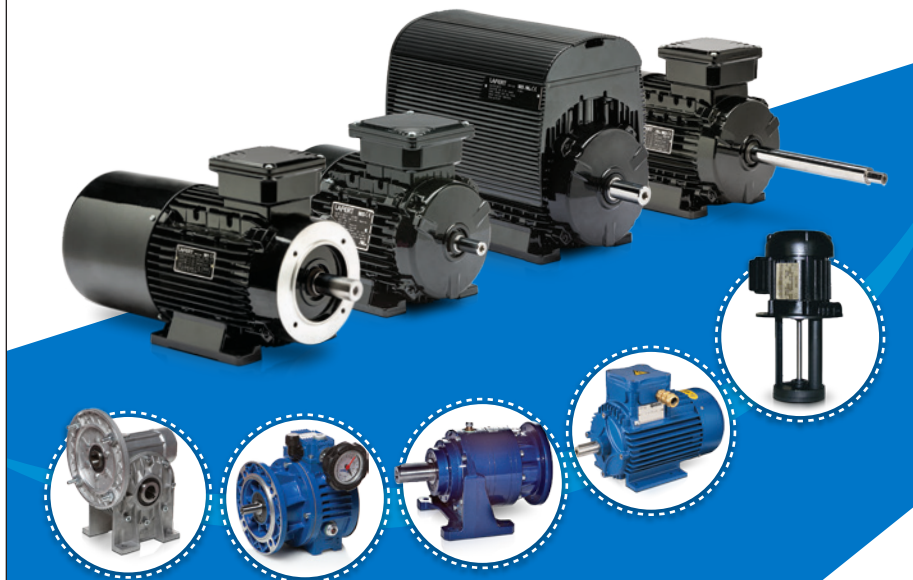
Phillips said that with manual lubrication, technicians tend to lubricate on schedule rather than when the bearing actually needs it. This can lead to a technician either over-lubricating or under-lubricating components. Automated lubrication provides lubricant in the right amount at the right time, allowing the bearing to operate optimally. When the bearing is properly lubricated in this

manner, it also helps to seal the bearing from contaminants.

“Automated lubrication can reduce annual bearing and lubricant costs, as well as the maintenance costs associated with unnecessary bearing replacement. It also allows machines to maximize uptime and, in turn, increase productivity and throughput. Automated lubrication can also address environmental concerns due to product spoilage from excess lubricant,” said Phillips.

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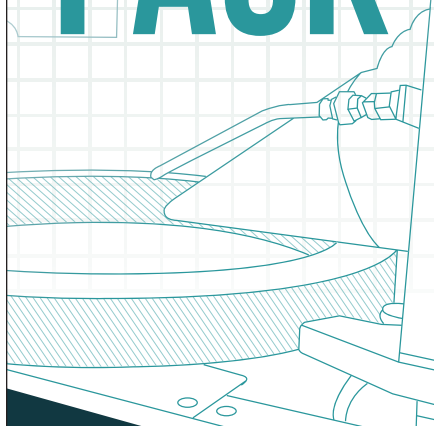
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An Evolving Technology

Phillips points to the fact that automated lubrication systems can now be remotely monitored and retrieve data. Workers can monitor lubrication systems in difficult-to-access locations and provide communication between the user and lubrication pump. “Having the ability to see if a system is functioning correctly or whether the reservoir is low or empty, has added tremendous value for our customers. Filtration and flow detection have also increased the effectiveness of these systems,” he added.

As they incorporate advances in technology, French agreed that lubrication systems are becoming “smarter,” which enable them to offer more value to the user. Features such as back pressure warnings, improvements in operating temperature range, the ability to input/output PLC control signals, integration with the cloud and analysis systems are just a few of the features maintenance engineers have at their disposal.

“Another evolution is the ability to program multi-point lubrication systems via software, instead of the old method of dip switches or manipulating mechanical ports. It’s important to ensure that each improvement provides not only functional value, but also improves the customer’s overall product experience,” French said.

Smart Data & the New Manufacturing Norm

This IIoT and smart manufacturing push is providing greater advancements in lubrication today. Additionally, robotics and automation are playing a significant role, according to Phillips.

“Approximately 90% of systems we sell today are automated. We will soon be launching a new digitalization product that can be controlled remotely—and we do have semi-robotic systems that can detect and grease chains and bearings while in motion. In the near future, we will be able to communicate directly with the pumps from a remote location to manage and operate the system,” Phillips said.

French said believes that automatic lubricators keep automation and robotics systems—including CNC machines, linear rail, gearboxes, cooling fans, robotic handlers, conveyor belts, etc.—operating at peak condition. All of these systems require regular lubrication.

But it’s data management that will certainly change lubrication long-term.

Phillips said that data is the key to the future of automated lubrication systems. Now, data is everywhere—and knowing what data to look at, how to use it and when to take action is imperative. Analysis of data will better educate us on the lubrication needs of machines, resulting in better systems to meet these needs.

Lubrication systems are becoming smarter which provides greater value to the user (photo courtesy of Schaeffler).



For example, Phillips said that demand lubrication based on real-time heat and vibration analysis will help drive additional efficiencies. As system recognition increases in motor amps and bearing stress indicators, it automatically increases the amount of lubrication events to manage these damaging factors through predictive maintenance.

Smart manufacturing integrates various monitoring and maintenance technologies (torque sensors, vibration monitoring, speed sensors, etc.) and uploads their data to the cloud (IIoT) where it can be analyzed to detect trends, track emerging faults and allow maintenance planners to efficiently schedule repairs.

“This same feedback is used to drive advancements in lubricator technology,” French said. “An example would be “demand-driven” lubrication, whereby inputs from sensors on the operating equipment (or from the cloud analysis software) detect subtle changes in equipment operating condition and signal the lubricator when the machine needs grease.”

Future Considerations

The new digital world is here — and it is important to advance with it. Phillips said that data and data analytics will play a major role in how we deliver innovation to our products and processes. Adoption of automated lubrication systems will continue to rise in order to increase bearing life while reducing maintenance costs.

“The ability to track data and receive live performance updates with connected and wireless automated lubrication systems will drive demand. These increased efficiencies through data analysis will allow companies to remain competitive in today’s global marketplace,” Phillips said.

Long-term environmental sustainability is very important; as such, it is receiving renewed industrial focus.

“We see it with the development of more environmentally friendly lubricants and lubricant waste reduction programs,” French said. “By delivering the *right amount* of the *right lubricant* at the *right interval*, automatic lubrication systems play a key role in reducing

waste and helping to achieve these vitally important goals.”

Furthermore, French said that continued integration with other predictive maintenance devices, cloud computing and analysis techniques will continue to drive the change from “smart machines” to smarter, greener “factories.” **PTE**

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Product Spotlight: Automatic Lubrication Systems

Schaeffler

Schaeffler offers two types of lubrication systems, single- and multi-point. Single-point devices thread directly into the lubrication port and are very versatile, as they can seamlessly enhance or replace manual lubrication programs. Highly suitable for typical drivetrain equipment (electric motors, pumps, fans, blowers and gearboxes), they can also be deployed to reliably lubricate hard-to-reach, elevated or safety risk areas. Available in gas or motor-driven versions, they are easy to install, easy to maintain and extremely reliable.

The multi-point systems can lubricate eight or more points from a central source. Each point receives the precise amount of lubrication at pre-programmed intervals. Both single- and multi-point systems can operate as stand-alone units, or they can be connected and controlled via PLC.

The process of looking into an

automatic lubrication system starts with a meeting.

First, we meet with clients to discuss their objectives, their current lubrication program as well as what products we bring to the table to make sure we're a good fit. Next, we gather information and survey the application to ensure our technical solution meets the customer's goals. From there, we build a customer-specific proposal that we discuss together. This gives the customers the opportunity to ask questions before we agree on the scope of supply," French said. "The last step is order acceptance and implementation, including hardware delivery and commissioning—either by the customer or Schaeffler staff as agreed during the proposal."

The cost savings that are achieved depend on a variety of factors such as the number of lubricators installed, downtime cost per hour, personnel cost per hour, component replacement



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Schaeffler customers that implement automatic lubrication programs benefit from longer bearing life and fewer failures.

costs, just to name a few. All are used to calculate the potential return on investment for the customer. Of course, each situation is unique.

“Customers who implement automatic lubrication programs typically enjoy many benefits,” French added. “On the mechanical side, customers typically benefit from longer bearing life as well fewer catastrophic failures. This allows customers to reduce their spare parts inventory. On the personnel side, workplace safety is enhanced, the number of unexpected shutdowns declines (which frees up resources), and planned maintenance is executed more efficiently. It’s a cascade effect of positive benefits, all of which are associated to overall cost reduction.”

SKF

SKF has both single-point and multi-point automatic lubricators that can be either gas-driven or electro-mechanical and range from one to 1,000



points. The systems offer oil circulation with temperature control/water and sediment removal. Typically, PT applications are highly specific and require engineered, custom-designed solutions. This can include a range of different controls, from local systems controls to programmable logic controllers (PLCs).

A successful lubrication program at SKF begins by assessing the plant’s daily workflow and business strategy for plant or machine maintenance. SKF then performs both a lubrication audit and needs assessment followed by a consultation that explains the program’s ROI. Some of the key factors to consider when formulating a lubrication strategy include proper lubricant selection, environmental factors, regulatory issues, storage and handling, training and performance and monitoring and assessment.

“Automated lubrication can lead to a 50% decrease in bearing failures and the maintenance time required to install them. It can also reduce the number of workers who run “lube routes” by walking through the plant and lubricating hundreds of points per shift,” Phillips said. “Manual lubrication also raises safety concerns, since lubrication may require a lift or ladder. Since machines typically need to be shut down during lubrication, it can also reduce productivity. Savings to the customer in a power transmission plant can be significant with an automated lubrication system.” **PTE**



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6 Critical Grease Characteristics

Dr. Kuldeep Mistry, The Timken Company

6 Critical Characteristics of Bearing Grease: Testing for The Optimal Blend

Whether you design, build or maintain industrial equipment, it is likely you have encountered many types of bearing grease over the years. Lubrication plays a crucial role in virtually all operations, and certain key characteristics allow grease to perform its job better in demanding applications.

Bearing greases are expected to meet an array of functional requirements including oxidation and corrosion resistance, wear resistance, water resistance, mechanical stability and low friction torque. Greases must also handle a wide range of operating temperatures. And while the right grease can significantly extend bearing life, protect your equipment and reduce costs, it can be difficult to know if your grease formulation is the optimal mix for the environment it is exposed to.

At its headquarters facility in North Canton, Ohio, The Timken Company operates a tribology and lubrication laboratory for conducting research on interacting bearing surfaces and the behavior of various greases and oils. By studying how lubrication and the design of bearings influence friction and wear, Timken can identify specific grease formulations that can maximize component life in everything from rolling mills to race cars.

Gaining a stronger appreciation for grease starts with understanding the criteria that govern its effectiveness. This article looks at primary grease characteristics and how testing can reveal which blends will outperform others without bringing busy plants and factories to a grinding halt.

Film Thickness Formation

Film thickness formation is a vital property for any grease or lubricant as it keeps bearing surfaces separate to minimize wear. In bearings where the correct film thickness is achieved, it becomes much more likely the bearing will reach its expected service life. Increasing film thickness, however, increases friction and drag inside the bearing, thereby reducing its efficiency. Meanwhile, an insufficient film will cause metal surfaces to rub together, leading to severe damage modes and early bearing replacement.



While grease selection can be a dirty job, choosing the ideal lubricant can mean a clean bill of health for hardworking bearings.

Viscosity—the measure of the flowability of a lubricant—is a major factor in film thickness formation. A high viscosity index—meaning the viscosity of the lubricant does not change radically when subjected to temperature changes—is generally preferred to get machines running at low-temp start-up conditions and keep them running at high-temp conditions. By knowing the load, speed and temperature requirements for your application, it becomes a practical matter to select a grease having the right viscosity to essentially control film thickness formation.

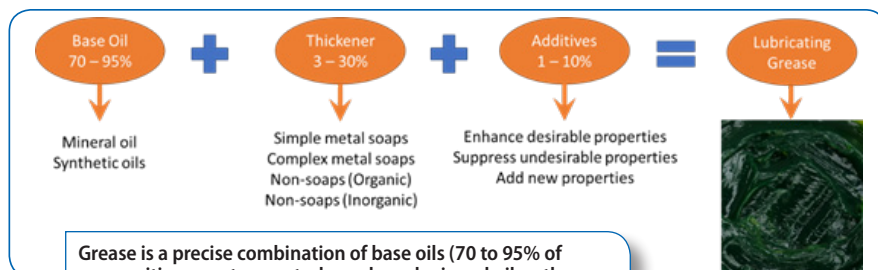
While there is no industry standard test to determine film thickness formation, there are many specially designed measuring devices used by bearing manufacturers to define operational values. In many cases, a purpose-built bearing test rig can predict the film thickness for a specific grease with extreme accuracy.

Consistency and Mechanical/Shear Stability

Consistency (hardness) is the degree to which grease resists deformation when force is applied. Consistency characterizes the plasticity of a solid in much the same way that viscosity characterizes a fluid. The measure of consistency is called penetration.

Penetration is expressed by the National Lubricating Grease Institute (NLGI) number system that categorizes greases by their hardness. Greases are assigned a “grade” based on ASTM D217 testing, a standard measure of consistency. The harder the consistency of the grease, the higher the NLGI grade. The NLGI scale ranges from 000 (semi-fluid) to 6 (solid).

Penetration is a critical grease characteristic because lubricants must remain at the bearing contact surfaces (where rolling elements contact the raceway), especially in



Grease is a precise combination of base oils (70 to 95% of composition; most are petroleum-based mineral oils, others are synthetic oils), thickening agents (3 to 30% of composition; agents include soaps, complexes, mixed soaps and non-soaps) and additives (1 to 10% of composition; there are many types from oxidation inhibitors to anti-wear additives).

applications where extreme loads and speeds work to push grease out of the bearing. What no equipment owner wants is a scenario where grease must be constantly pumped into the bearing to prevent early damage onset. Depending on the mounting orientation of the bearing, gravity can also cause grease to move away from contact areas, making it even more important to achieve the ideal consistency.

Grease consistency is usually measured by cone penetration according to ASTM D217 or ASTM D1403. ASTM defines penetration as the depth that a standard cone penetrates a sample of lubricating grease under prescribed conditions of cone weight, time and temperature. Penetration is measured in tenths of a millimeter, sometimes abbreviated dmm. Tests can be conducted for unworked, worked and prolonged worked penetration, with worked penetration (where grease is first subjected to 60 double strokes in a standard grease worker) being the most common test.

Mechanical stresses can reduce lubricant viscosity as grease is worked between bearing surfaces, making shear stability another vital grease characteristic. ASTM D1831 offers a test method to determine changes in the consistency of greases (as measured by ASTM D1403) when worked in a roll stability test apparatus. Test results can reveal a directional change in the consistency of the lubricant that could occur in actual service, helping equipment owners avoid costly problems caused by thinning grease.

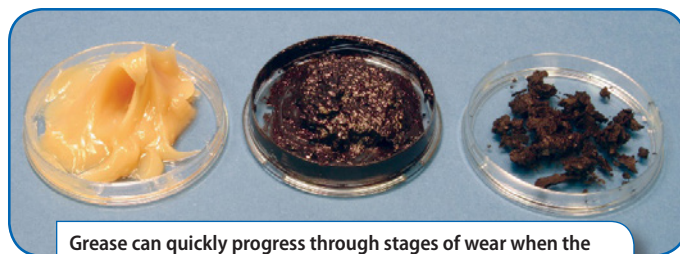
Oxidation Stability

Grease oxidation, which is a time- and temperature-dependent phenomenon, directly affects grease life by diminishing its ability to form an effective lubricant film on bearing contact surfaces. A grease consequently requires significant oxidation stability to operate in applications with high operating temperatures and long service period requirements.

A reliable method of measuring grease oxidation stability is ASTM D5483 testing using pressure differential scanning calorimetry or PDSC (a calorimeter measures the heat involved in a chemical reaction or physical process—a pressure differential scanning calorimeter measures the effects of surrounding gas pressure on these measurements). This method is commonly used to compare grease oxidation resistance and predict the relative life of the lubricant. ASTM D5483 evaluates the oxidation induction time of lubricating greases using PDSC, where the induction time is used as a measure of oxidation stability.

In this test, a grease sample is placed in a cell that is heated to a specified temperature (commonly 150°C or above) under pressurized conditions (e.g., 500 psi) until an exothermic reaction occurs in the presence of oxygen. The oxidation onset time is then measured, with a longer induction time indicating longer grease life.

To prevent oxidation from becoming a problem, it is advisable to keep your bearing seals in good condition and to avoid unexpected temperature spikes by taking correct steps such as proper bearing installation, grease selection and grease-fill. Air can easily infiltrate through defective seals, enabling oxygen and hydrocarbons to react and form oxidation products that degrade the bearing grease.



Grease can quickly progress through stages of wear when the formulation fails to meet bearing operating requirements—the result being an expensive repair in many cases.

Rust and Corrosion Resistance

Moisture and water ingress can lead to corrosion or water etching on the contact surfaces of bearings and typically occurs when the bearing is stationary for prolonged periods. Severe corrosion can cause pitting of metal surfaces, thereby increasing the risk of surface or subsurface fatigue damage. Thus, the degree of rust and corrosion protection provided by bearing grease is a major consideration.

ASTM D1743 and ASTM D6138 are two standard rust and corrosion tests. ASTM D1743 is a static test of a grease-packed roller bearing for 48 hours under 100% humidity at 52°C. Conversely, ASTM D6138 is a dynamic test of the grease's corrosion preventive properties. This test, also known as EMCOR, involves testing the grease packed in a double row of self-aligning ball bearings at a speed of 80 rpm (cycled) under no load, without heat and in the presence of water. In both ASTM D1743 and ASTM D6138, the outer rings are respectively examined for corrosion.

Timken has developed special tooling with some alteration to conduct ASTM 6138 testing on roller bearings using distilled water, synthetic seawater and sodium chloride to determine how different levels of aggressive fluids impact grease corrosion resistance. The results of this analysis have helped many customers avoid the cost of purchasing new bearings that would have continued to fail due to inadequate corrosion protection of the grease.

Extreme Pressure Performance and Wear Evaluation

Some greases use extreme pressure (EP) additives to create a tribochemical film between contact surfaces (tribochemistry being concerned with chemical reactions triggered by mechanical forces). Greases that break down under extreme pressure increase the likelihood for scuffing (abnormal wear due to localized fracturing) and spot welding to occur, which can abruptly end a bearing's effective life.

ASTM D2596 is commonly used to determine the load-carrying capability of greases under pure sliding contact. Using a four-ball extreme pressure tester, grease samples are subjected to a series of 10-second tests at increasing loads until welding occurs. The weld point is then recorded. The higher the weld load, the better the grease for extreme pressure protection.

Meanwhile, ASTM D2266 is used to evaluate the wear-preventive characteristics of greases. This test mirrors ASTM D2596, except that it measures wear resistance at a lower load over a longer time, and welding does not occur. As an example, a grease under 4-ball sliding contact (where a steel ball is

rotated against three stationary steel balls having a lubricant film) will be tested for 60 minutes at 1,200 rpm under a 40-kg load. Wear scars on the stationary balls are then measured, with smaller-size wear scars indicating that the grease offers superior protection.

Note that more EP additives do not always equate to a better performing bearing grease. In fact, greases having too high an additive concentration can increase the potential for aggressive chemical reactions, to the point that damage modes like micropitting (seen as small craters on contact surfaces) become a concern. This unintended consequence of grease selection can be the difference between a bearing that performs for 100 million cycles and one that lasts 200 million cycles more. Like most aspects of grease formulation, the need for EP additives must be carefully balanced against other operational requirements.

Extreme Temperature Performance

Many industrial machines must endure extreme low temperatures, making some synthetic greases a strong choice for achieving good flow properties even at -50°C.

ASTM 1478 is a grease low temperature torque test that investigates the ability of a grease to lubricate a slow rotating ball bearing. The test records starting and running torques at temperatures below -18°C and provides an accurate data point for selecting grease for a wide range of applications. At -18°C, many standard greases approach their pour point, where the grease can no longer flow. When greases congeal and bearings seize up, companies can lose days of production time, and the problem is not uncommon.

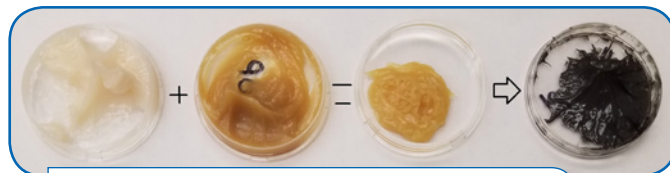
Meanwhile, the dropping point of a grease — the temperature at which it transitions from a semisolid to a liquid state (where the base oil leaves the grease thickener) — gives good insight into high temperature performance.

ASTM D2265 is a standard method for measuring the dropping point of grease. In this test, grease samples are gradually heated until the thickener can no longer hold the base oil and drips start to occur. The market offers many ultrahigh temperature greases that can withstand temperature spikes over 400°C; however, a consideration of overall grease performance is key.

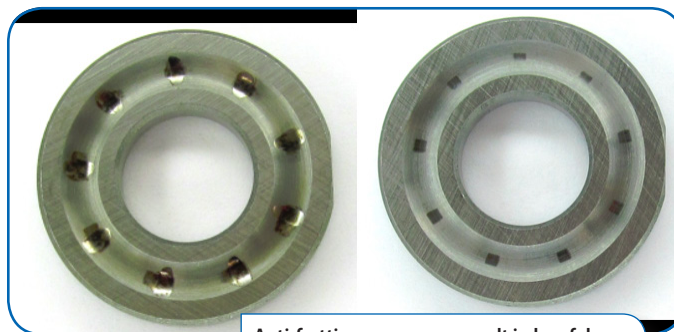
Additional Considerations

There are many more tests to determine other grease characteristics such as water washout (the ability of a lubricant to resist being removed from a bearing when acted on by a stream of water, governed by ASTM D1264); grease compatibility (where the properties of different mixtures can be incompatible, leading to an assortment of problems, see ASTM D6185); seal compatibility (measuring the changes in the volume and hardness of an elastomer immersed in grease to evaluate its relative compatibility, see ASTM D4289); and fretting performance (how well grease can tolerate the effects of sliding and vibration where bearings oscillate, see ASTM D4170).

Turning to a knowledgeable lubrication resource can help you overcome issues you may be experiencing with bearings. Oftentimes, bearing failures are the result of poor lubrication



Compatible greases (top) will appear similar after several hours of operation whereas incompatible blends (bottom) can result in darkening of the grease due to mechanical degradation, oxidative degradation, starvation and/or wear debris, thus leading to bearing damage.



Anti-fretting grease can result in less false-brinelling wear compared to a typical EP grease when tested under ASTM D4170.

practices or improper grease selection — situations that can be remedied with the help of an expert professional who understands your unique operational requirements or production demands. Most greases look the same, but no two formulations are perfectly identical. Dialing in the optimal blend for your application is possible with grease testing that is available from many lubricant makers and bearing manufacturers. **PTE**

Grease Glossary

There's a lot to know about grease — the Lubricants Glossary (autoam.timken.com/techseries/lubricant_pages/lubricant_glossary.htm) is part of the free Timken Tech Series (www2.timken.com/testing/index.asp) and explains common terminology.

Kuldeep Mistry, Ph.D., is a research and development specialist for The Timken Company focusing on lubrication solutions for heavy-duty applications.

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High-Performance Plastics

Custom PEEK Compounds have led to the development of transmission seals and thrust washers that offer lower wear, friction and temperature advantages

Matthew Jaster, Senior Editor

There's nothing wrong with off-the-shelf material solutions. They are readily available and provide proven application results. Look closer, however, and you'll find that off-the-shelf solutions are always compromising, according to Ray Szparagowski, technical director of automotive and high-performance plastics global fluid power division at Freudenberg-NOK Sealing Technologies.

"Customers are always making decisions on the validity of their product technologies," Szparagowski said. "Can I live with this amount of leakage? Can I live with this amount of tolerance? Can I live with this amount of clearance? But when it really comes down to making these products as efficient as possible, customization is probably a safer bet."

Material developers at Freudenberg have developed PEEK compounds that are precisely tailored to the respective application. The resulting transmission seals and thrust washers are characterized by lower wear, lower friction and lower temperature development. The company has spent years developing special filler packages for new high-performance plastics (HPP) that focus on sealing rings and thrust washers used in automatic transmissions.

Szparagowski uses a basic seal ring as an example. "Let's say I need a seal ring to fit in a groove and that groove is very large and oversized. The customer is going to pay more for the material I need to make the seal out of. They're also going to have a higher contact area on the sides of the running surfaces, so getting rid of friction is going to be an issue even with a low-friction material. However, if they let me go in and redesign the space needed, I can provide a cheaper part with less material that offers less surface contact and lower temperature. This customization gives you an opportunity to be much more efficient when it comes to cost and performance," he said.

A Custom Request

Several automotive customers had concerns about products that weren't optimized to match specific component and application needs. Szparagowski said that Freudenberg developed materials that can save the customer money and reduce friction and heat to be much more efficient than off-the-shelf solutions.

The new materials are based on precise knowledge of their application. To optimize the material properties, the experts at Freudenberg Sealing Technologies improve the base polymer with various ingredients. Fillers such as graphite or glass and carbon fibers, for example, can reinforce the material, reduce friction and wear, or produce conductivity. Additives such as pigments, waxes and stabilizers influence

crystallization and flow behavior, while different colors enable the correct assembly of the component. The resulting HPP materials are precisely tailored to address current and even future application challenges.

"The biggest benefit here is the efficiency savings. These customized technologies can save money by not only providing lower hardness shafts, but rougher surfaces so the automotive customer doesn't have to machine to a precise tolerance on a finish. We can extend the envelope of the material to higher pressures and higher velocities without concerns of failure," Szparagowski said.

One example is the new material Quantix 55-14, which was developed on the basis of the high-performance polymer PEEK. This material is also known as "Low-Hardness PEEK" and reduces metal wear when it comes in contact with steel components. The engineers at Freudenberg Sealing Technologies in Findlay, Ohio, used the material to manufacture sealing rings that function as hydraulic rotary feedthroughs that contain the oil between the clutch and the interior of the transmission shaft in automatic transmissions. The lower incidence of system wear produced by Quantix 55-14 reduces hardness requirements for shafts and lowers customers' production costs.

Freudenberg's Levitorq thrust washers also use Quantix 55-14. The flat, disc-shaped components are used in torque converters and automatic transmissions where they absorb axial forces from rotating components. Friction needs to be as low as possible in these applications. When the shaft starts to rotate, Freudenberg's patented groove technology allows fluid to pass under the washer. This creates a hydrodynamic lubricating film that lowers friction and reduces wear in the application. If conditions prevent operation in



Freudenberg has developed PEEK compounds specifically tailored to an application.



The benefits of these custom components includes providing a database of how different seals and rings operate in the field.

the hydrodynamic range, the material's very low, dry friction will increase durability.

Both applications use a similar principle, according to Szparagowski. "Try to let the fluid do the work for you to lower the friction. In the example of our Levitorq thrust washers, we can reduce the friction of traditional designs by 7-10 times."

The result is a significant savings when it comes to energy efficiency and CO₂ in vehicles. Everybody is looking to improve gas mileage in 2019, so Freudenberg's automotive customers can take advantage of this technology to improve in these areas.

Material experts at Freudenberg Sealing Technologies have conducted comparative wear and friction testing on thrust washers made from Quantix 55-14 and those made from readily available, HPP materials designed for applications that require low friction and wear. Thrust washers made from Quantix 55-14 demonstrate a 95-percent reduction in wear, a 55 percent reduction in friction and a decrease in temperature at the interface by 35°C.

Gaining Knowledge & Experience

The obvious benefit to providing a customized solution for an automotive customer is the knowledge gained with each individual assignment.

"We've been involved with transmission seal rings for many years," said Szparagowski. This has provided us with different conditions and scenarios to learn more about how these products operate in the field. We're also significantly invested in testing and evaluation, building our own models for predicting fluid film generation, for example. We have set up very high standards for understanding when failure modes occur and if they do. We can offer analysis and evaluation of thrush washer applications to a high level because we understand how these things work and how to address any of our customers concerns."

More Opportunities for HPP

So, what's next for Freudenberg-NOK Sealing Technologies? Szparagowski said that the company will continue to push the envelope on how high they can take the pressure, velocity, and temperature ranges of their products.

"We expect to continue to move parts that are metal today into plastic. Over time, you're going to see less metal and

more high-performance, highly engineered materials being used. This will occur because of all the weight, size and efficiency benefits," he said.

Additionally, the company's next generation of Levitorq is coming. Szparagowski said that certain customers have applications where lubrication is very sparse and hard to get fluid near the bearings, so they're developing patent-pending technology to collect that fluid and use it to pull it under the washer and allow this product to run at much higher velocities then could be traditionally done.

"We took a critical area of failure and improved it through our design," Szparagowski said. "I expect that we'll find several years from now we'll have the next generation of these bearings that will be able to take on even more aggressive conditions."

While the Levitorq is an axial thrust bearing, the company is trying to do some advanced work in radial bearings. Szparagowski said, however, that there a lot more complications in these designs and much more work to be done. They believe they will expand their portfolio to include radial bearings in the future.

The company is also looking into ultra-thin bearing applications. Many bearings today need many millimeters of space and Szparagowski thinks they can use these plastic materials and very thin cross sections (say less than a millimeter) and save space and still get the low friction and performance benefits.

"We have work to do in both those areas that could really change the nature of how a bearing looks in the future," Szparagowski said. "This could expand our opportunities to offer better customized solutions." **PTE**

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A Better Way to Measure High-Performance Plastics Means Performance

Dr. Sai Sundararaman, Freudenberg-NOK Sealing Technologies.

In today's manufacturing environment, and especially in the automotive industry, the benefits of high performance Plastics (HPPs) are driving an ongoing increase in their use. Use of these materials in design and engineering applications provide flexibility, a high strength-to-weight ratio, improved tribological performance and unique chemical formulas that meet a variety of performance requirements. Usage is further being driven by pressure on OEMs to reduce vehicle weights, cut CO₂ emissions, reduce system friction and heat, increase long-term material compatibility and control costs.

While the advantages of HPPs in manufacturing are clear and real, traditional standardized methods for testing the tribological performance of plastics as a measure of part performance in the end application are often less than reliable. Additionally, traditional test methodologies are slow — taking up to five days to yield results — and generally accommodate only four tests per month. This time limitation significantly slows the production development cycle for OEMs.

A challenge

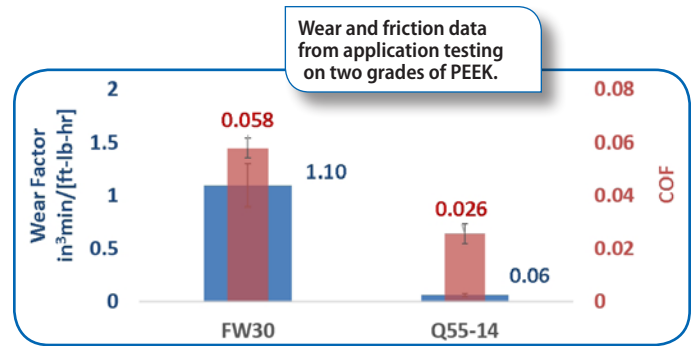
Consider the recent challenge faced by an automotive OEM that needed to reduce production time and costs in the manufacturing of its transmissions. To avoid regrinding the transmission shafts after outsourced heat treatment, the OEM chose to move to a softer metal for its shafts that didn't require these steps. The softer material also required a change to HPPs sealing elements with the correct tribological performance to prevent surface compatibility issues between the seals and the shaft. Using standard test methods to find the right plastic could have taken months. The OEM needed an accurate but faster solution.

A better way

In developing a new methodology, it was essential to increase the intensity of testing without altering failure mode — the accurate measure of the wear of the plastic. Many existing methods currently in use confuse wear failure with the creep, or melting, of plastic.

Freudenberg Sealing Technologies began work in 2016 on the development of new test methods for HPPs. The company's customers were exploring the use of HPPs in powertrain and hydraulic systems to solve a variety of environmental and performance challenges. Scientists worked closely with material engineers to study the test methods being used in the U.S., Germany and Japan. By extracting and combining critical processes from these methods, Freudenberg developed a new approach to test HPPs.

The methodology delivers reliable, accurate, real-world results in a fraction of the time normally required for traditional HPPs testing. When the automotive OEM working on transmissions approached the company about HPPs



compatibility with softer metal shafts, the company was able to identify an optimal solution within a short period of time.

Why it's better

While faster is important — reducing testing time from five days to four hours, allowing for two tests per day — so is test accuracy. The HPPs test methodology that was developed generates extremely accurate performance data.

Wear and friction characterization of HPPs is complicated because they are dependent upon a number of system parameters including loads, speeds, temperatures, roughness/hardness, material geometry and others, which can change significantly based on application. Accurate evaluation of tribological performance of HPPs needs to account for these variables, as recommended in this innovative methodology, enabling it to be predictive of part performance.

Environmental advantages

This improved test methodology facilitates real environmental advantages as well. A recent study published by Holmberg and Erdemir (Ref. 2) on the effect of friction and wear on energy consumption, economic expenditure, and CO₂ emissions, concluded that 23 percent of the world's total energy consumption in the transportation, manufacturing, power generation and residential sectors results from tribological contacts.

Through the appropriate application of tribological technologies, CO₂ emissions and the related economic costs could be significantly reduced — with those improvements underpinned by more accurate testing and reliable results. As shown in the application example in the figure below, changing material essentially reduced friction by approximately 55 percent. This means that the CO₂ emissions are also proportionally reduced. Existing and commonly used tribological testing methodologies often fall short of the needs of OEMs and their customers. This innovative approach in testing saves manufacturers time through accelerated product development cycles, improved industry performance and numerous environmental improvements. It's good for manufacturers, good for the industry and good for the world. **PTE**

References

1. Sundararaman, S., "Improved Test Method for Tribological Evaluation of High-Performance Plastics," SAE Technical Paper 2019-01-0183, 2019, doi:10.4271/2019-01-0183.
2. Holmberg, K., and Erdemir, A., "Influence of Tribology on Global Energy Consumption, Costs and Emissions," Friction, Vol. 5, No. 3, pp. 263-284, 2017.

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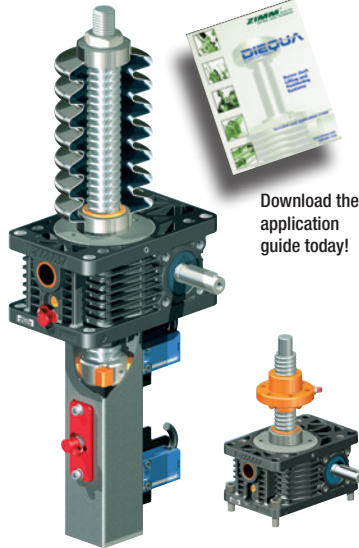
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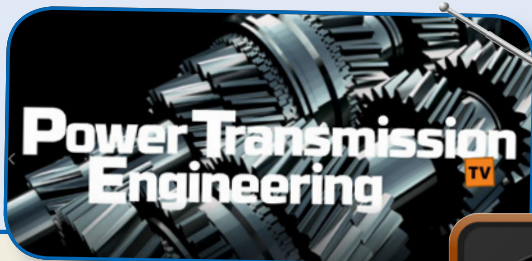
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Bearing Materials and Coatings Trends

THE QUESTION

What trends do you see in bearing materials and coatings that will benefit the power transmission industry?

EXPERT RESPONSE PROVIDED BY GUILLERMO E. MORALES-ESPEJEL. In general, many of the mechanical components in the power transmission industry are suffering from harsher tribological conditions, e.g. — rolling bearings and gears need to take/withstand higher power density, higher temperatures, dynamic loads, particle contamination and thinner or insufficient lubricant film. This follows the trend of the current economic constraints and tighter environmental policies. It is common now to see engineers struggling to design power transmission devices that consume less energy, last reliably longer and waste no lubricant. Hybrid contacts (silicone nitride with steel) are excellent solutions in these conditions — in particular, rolling bearings can take advantage of this because they are historically (for the past several decades) manufactured in a reliable way. Costs are also going down, as manufacturing techniques and materials are improved. Bearing life can now be estimated for those hybrid bearings, i.e. — SKF GBLM.

However, today's high speeds or/and high accelerations impose high heat inputs on surfaces, which might lead to adhesive wear and seizure. For that, coatings like special DLCs — that feature wear-resistant, metal-containing hydrogenated amorphous carbon coatings that are applied to the rolling element surfaces — are a good solution. Alternatives that can work well, depending on the conditions, would be black oxide and manganese phosphate coatings. If no coating is used, then steels with high thermal conductivity are preferred, as they can evacuate the heat at the surface in a fast and efficient way. Metal powder technology also offers good solutions here. **PTE**

Guillermo E. Morales-Espejel is an SKF Research and Technology Development, Principal Scientist.



Black-oxidized wind turbine gearbox bearings: cylindrical roller bearings without outer ring, used in planetary wheels. (Photo courtesy SKF.)

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Motors without Rare-Earth Magnets: What Are the Options?

Lower-cost motor technologies exist that can be an attractive alternative to neo-based BL PM motors — and are not subject to unpredictable supply chains

George Holling

Almost no day passes without a major news article that discusses the very real possibility that China may use its rare earth supply as a weapon in the ongoing trade war.

Neodymium and related rare-earth materials are key elements in the manufacture of powerful magnets that are used in many products — from consumer electronics, medical equipment, and automotive components to military weapons. Thus, any disruption of the supply of rare earth commodities will have a far-reaching impact on our lives.

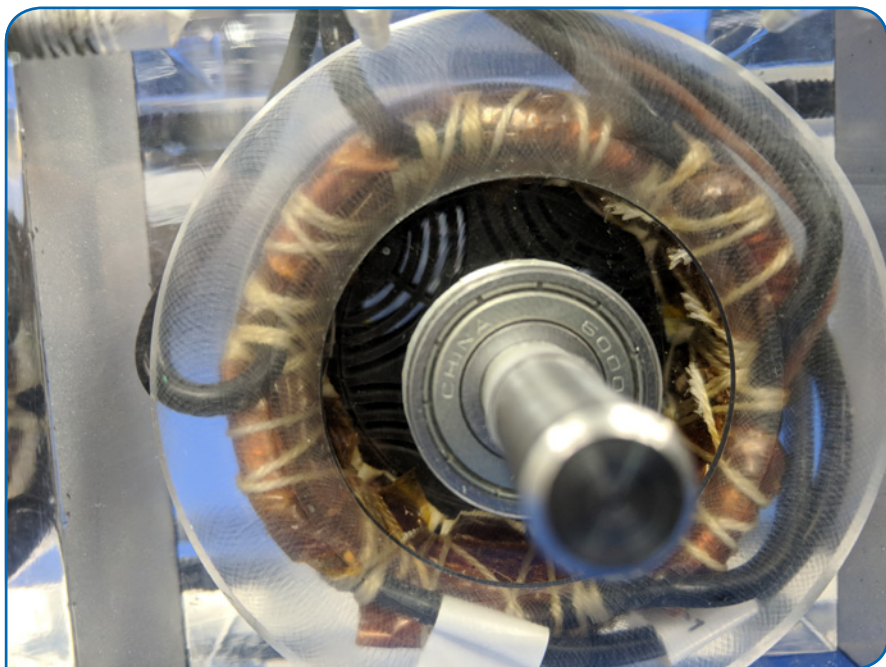
First, what are rare-earth materials and why can we not mine them in the U.S.? The rare-earth materials that we are mainly concerned with in this article are the elements neodymium dysprosium and praseodymium. As mentioned, these are the key components in the manufacture of powerful magnets which in turn are used in many products. The actual raw materials are available in several countries, i.e. — Russia, China, Thailand and the U.S.

In fact, the U.S. has a large supply of these materials that could be readily mined. However, mining rare-earth materials is a “dirty” process and often not environmentally friendly. This, in combination with the high cost of complying with environmental regulations, has made the domestic production of these minerals not economically viable.

It must also be understood that even if we relaxed these regulations and raised the price of rare-earth materials, it will take 5–10 years to start viable commercial mining and production of a domestic rare-earth supply. In the meantime, we are forced to rely on foreign supplies — or find alternate technologies that do not require rare-earth magnets.

In this article we will focus on a type of electric motors that is one of the main consumers of rare earth magnets. Neodymium magnets contain several rare-earth materials in different ratios that will impact the characteristics of these magnets, such as energy product, temperature stability, etc.

Let us first briefly review the different, applicable types of electric motors: AC induction (AC), synchronous AC, brush DC, brushless DC/AC (BL DC, BL AC), internal permanent magnet (IPM), variable switched reluctance, or simply



Synchronous reluctance motor (all photos courtesy George Holling).

switched reluctance (VSR) and the synchronous reluctance motor (SYR). There are, of course, many variants and semantic variation, e.g. — the IPM is also called a permanent magnet (PM)-assisted reluctance motor.

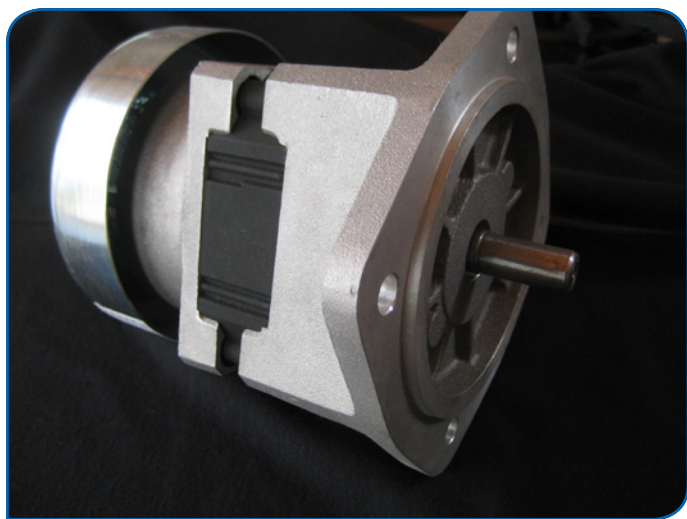
The ACI is a widely used motor that is, partially due to its simplicity, and partially due to the fact that it can run directly off a power line without requiring any control electronics, a very low-cost solution with moderate efficiency (80% for single-phase motor and low 90% for 3-phase motor).

Most everybody will be familiar with the AC induction motor; it is widely used as a single-speed motor and also as a traction motor in electric vehicles. The ACI requires at least two phases to develop starting torque. Three-phase motors will start from the line but may exhibit large starting current, and so start-up circuits are often added. The single-phase ACI is actually a 2-phase motor with a primary winding and an auxiliary winding — both of which are powered from the main line — but a capacitor is added in the auxiliary winding to produce a phase shift which thus allows the motor to start. Once the motor starts, the main phase will keep the motor running and the auxiliary winding is often disconnected via a centrifugal switch. The main drawback of the ACI is that it will only run at a single speed — unless controllers are added.

The brush DC motor is a low-cost motor type that we all remember from our childhood, as it can be found in many toys. Typically, a permanent magnet or a field winding is

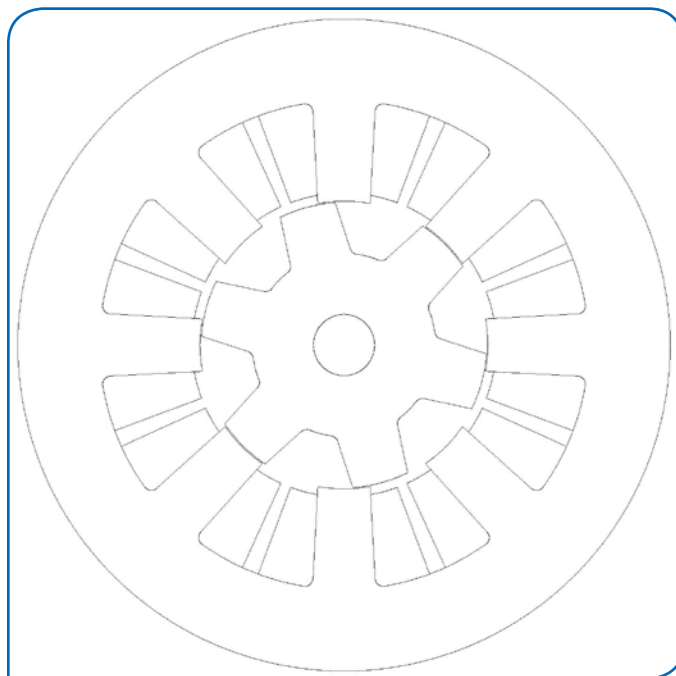
used to generate a magnetic field and the rotor has multiple poles that are connected to the power source via a commutator. As the motor rotates, the commutator will always energize the correct windings to produce torque. If a field winding is used, this can be connected in series (series motor) or in parallel (shunt motor) with the rotor. Brush DC motors are still widely used in, for example, golf carts and automotive and industrial applications where speed control can be cost-effectively accomplished. But the commutator is subject to mechanical wear and brush motors do not allow for high momentary torque overload, as these will damage the commutator. The rotor also has a high inertia and the overall efficiency a low (low 60% - low 80%), which renders the brush DC motor less than well-suited as an industrial servo motor.

The brushless PM motor has replaced many ACI and brush motors, and it is becoming the motor of choice for many important applications, such as traction motors in EVs, industrial automation, robotics and military systems. A magnet—typically a high-energy magnet—is placed on the rotor and the stator is similar to that of the ACI, except that a controller is used to determine the rotor position and to then energize the stator windings accordingly—either with a sine wave (BL AC) or a fixed current/voltage (BL DC). It must be noted that there will be some method of feedback



Switched reluctance motor.

to determine the rotor position and then energize the windings accordingly; therefore, this is an electronically commutated motor (ECM). It is also possible to simply apply a rotating field to the stator and then let the rotor follow this field, which is called a synchronous AC motor. A synchronous motor is less efficient and it must have—often significantly—more torque than the application requires in order to prevent it from falling out of synch. The BL AC motor is often called a synchronous motor, but that is incorrect; the



Drawing of 4-phase step motor.

BL AC motor is an ECM versus a synchronous motor. While the PMBL motor offers high efficiency (94% -98%), small volume, and light weight, it does, however, require a controller and often a feedback device that adds cost and complexity to a PMBL drive system.

The switched reluctance motor (SR) or, more correctly, the variable switched reluctance motor (VSR), is also a brushless motor that requires no internal magnets. The VSR has a stator where each coil is centered around a single tooth and a stator with a simple tooth structure. When a winding is energized, the rotor will align itself with the exciting teeth and, as it approaches this equilibrium, the coils are switched and the rotor will be attracted to the neighboring teeth. The VSR offers high power density and good efficiency (94% - 96%). But the VSR has some drawbacks; most often noted is its acoustical noise signature or audible noise that can be higher than that of other motor types. The VSR also requires a specialized controller where each motor phase is connected with two leads, rather than the one phase lead commonly found in the other motors. Furthermore, the VSR features a smaller air gap and requires tighter mechanical tolerances than other motor types, which can also add manufacturing cost.

The SYR is an emerging technology that has been known about for over 20 years—but has only recently attracted attention. The stator of the SYR is similar to an ACI or PM AC motor, but the rotor is simply a solid rotor with stamped slots that create a flux barrier and channel the flux through the rotor. Another construction uses laminated material in the x-y direction, but that is not practical to implement, although some researchers have shown it to work.

The SYR requires a controller — just like the PM BL motor. In fact, with minor software changes it can utilize the same controller as the BL PM motor. In all other respects it is also very similar to the BL PM motor, i.e. — acoustical noise — and it has been shown in many studies to offer a lower manufacturing cost than the BL PM motor. For smaller needs, (< 1HP), the SYR may offer slightly lower operating efficiency (upper 80% - 95%), compared to a rare earth BL PM motor, and it requires slightly better mechanical tolerances — but it will out-perform ACIs. We do not yet have sufficient data to compare the maximum operating efficiency for larger SYR motors, but we expect these to come closer to those of BL PM machines. The SYR also operates at very high efficiency — at speeds of 50 KRPM and higher — where it may actually out-perform a similar-sized BL PM motor.

The last motor type that we will discuss here is the internal permanent magnet motor. The IPM has a stator similar to the ACI and BL AC motor, and it has magnets that are embedded in slots in the rotor. The IPM is a hybrid between a BL PM (PM) and a SYR (rotor slots, flux barrier) motor, and therefore requires a controller, the appropriate control software, and somewhat tighter manufacturing tolerances. However, the IPM is probably the most efficient and highest-power density motor available to us today. While we will discuss this in greater detail in Part II of this article, it should be noted

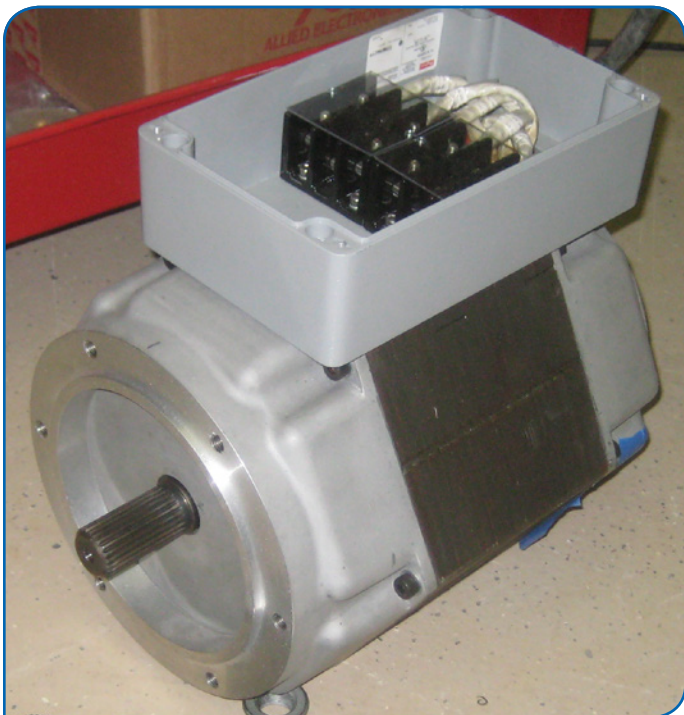


Key SR Element Switched Reluctance Motors.

that a powerful and efficient IPM can be constructed — even if less-powerful magnets are employed in its construction, e.g. — ferrite or samarium cobalt magnets — where the supply is not monopolized by China. Utilizing alternate magnets in the construction also allows for the design of very high operating temperature motors, unlike those that use neo-magnets that limit the maximum operating temperature.

Now that we have reviewed the available motor technologies, we will compare these motors in greater detail in Part II of this article and highlight how alternate motor technologies can be an attractive alternative to neo-based BL PM motors that are not subject to unpredictable supply chains.

Also in the second part we will focus on the SYR motor and the IPM with magnets that do not contain rare-earth materials and can be produced in the U.S. (*Editor's Note: Part II of this article will appear in the December issue of Power Transmission Engineering.*) **PTE**



65 KW IPM motor.

George Holling holds significant influence in two companies — as technical director of Electric Drivetrain Technologies (2011– present) Moab, UT and as CTO of Rocky Mountain Technologies (2001– present), Basin, MT; contact George Holling at George.Holling@RockyMountainTechnologies.com.

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General Modeling Method of Power Losses in Transmission with Parameter Identification

Ye Shen, S. Rinderknecht and Maik Hoppert

To reduce the CO₂ emission of vehicles, improvement is always considered for an energy-efficient ICE (internal combustion engine) or a substitutional EM (electric motor). But the optimization of efficiency is also necessary for all other components in the powertrain, no matter which motor concept is used (Ref. 1). One of the most relevant loss sources of the powertrain is the transmission. For example, if one energy unit in a manual or automatic transmission is saved, the engine input energy can be decrease by 2.5–4 energy units to achieve the same power output (Ref. 2). Thus, it is also an effective way to reduce the energy consumption through increasing the efficiency of the transmission, which means the power losses inside the transmission shall be reduced.

Although research on power losses of vehicle transmissions has been carried out for decades, the research focus is always the modelling of component power losses. On one hand, the procedure to estimate the overall power losses of the transmission is based on the sum of all the components power losses (Refs. 3–5). On the other hand, only the overall transmission efficiency can be obtained through most experiments. Therefore, this paper aims to develop a method to unify the component power loss models and the experimental results, in order to achieve a more accurate power losses prediction for the transmission. The method can be applied to different types of transmissions in a flexible way and provide a platform to compare several different products from different OEMs or suppliers in parallel.

Power Loss Mechanisms inside a Transmission

According to Niemann/Winter (Ref. 6), power losses in a transmission consist of load-dependent power losses and load-independent power losses, which originate from gears, bearings, seals and auxiliary power losses:

$$P_V = P_{VZP} + P_{VZO} + P_{VLP} + P_{VLO} + P_{VD} + P_{VX} \quad (1)$$

In Equation 1, gear losses are divided into load dependent power losses P_{VZP} and load-independent power losses P_{VZO} . The P_{VZP} is evoked mainly by the friction-related mechanical power losses in gear meshing (Refs. 3, 7–9). And the cause of P_{VZO} is the gear pair spin that is bathed in the lubricant oil or surrounded by an oil-air-mixture, like the oil churning losses (Refs. 10–12). Same as the gear losses, the bearing losses P_{VL} are composed also of load-dependent power losses P_{VLP} and load-independent ones P_{VLO} , which is well-described (Refs. 13–14). Seal losses P_{VD} and other losses P_{VX}

are not load-dependent (Refs. 15–16). For different transmission types, other losses P_{VX} can be losses of synchronizers or clutches. For the power loss calculation of the example transmission, gear meshing losses P_{VZP} , churning losses P_{VZO} and bearing losses PVL will be considered and therefore discussed in the next section.

Gear meshing losses. Power losses due to gear meshing result from the sliding and rolling of the two tooth flanks of the wheel and the pinion against each other on the path of contact (Fig. 1).

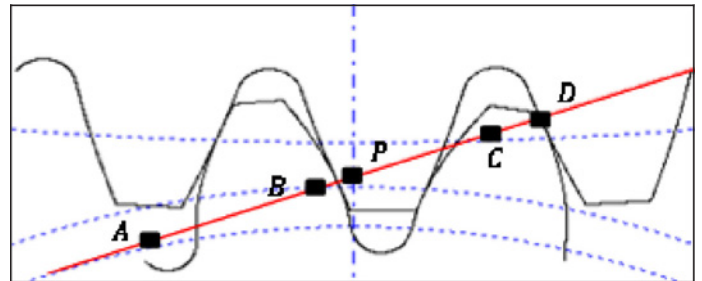


Figure 1 The path of contact between two tooth flanks of the wheel and the pinion.

A: the start point of the contact; B, C: point of the load switching; P: pitch point; D: the end point of the contact.

It is obvious that for each point x along the path of contact, the instantaneous power loss due to sliding is the product of the sliding velocity V_s , the coefficient of friction f and the tooth normal force F_n , shown in Equation 2.

$$P_s(x) = |V_s(x)| \cdot f(x) \cdot F_n(x) \quad (2)$$

Through tooth geometry and input rotational speed, the sliding velocity can be easily calculated. The normal force distribution is assumed to be ideal, which means the normal force between the tooth flanks from point B to C is constant and double the value of the one from point A to B and point C to D (Fig. 1).

Modeling of the friction coefficient is complex because it is affected by tribology factors like tooth surface structure, roughness, type and viscosity of the lubricant. Besides, it is also influenced by macro-geometric properties of the gear set. Various authors (Refs. 8, 17–20) developed models to predict the friction coefficient on the tooth flank. Among them, the model by Xu (Ref. 20) is obtained by using multiple linear regression analyses includes all the key features of a gear contact, based on the Newtonian thermal elastohydrodynamic

lubrication (EHL) model.

The instantaneous sliding power loss is then available through multiplying the sliding velocity V_s , the coefficient of friction f and the tooth normal force F_n . The average sliding power loss of the gear meshing \bar{P}_s is obtained by integrating P_s over the path of contact and then dividing by the length of the path of contact:

$$\bar{P}_s = \frac{1}{x_D - x_A} \left[2 \int_{x_A}^{x_B} P_s(x) dx + \int_{x_B}^{x_C} P_s(x) dx + 2 \int_{x_C}^{x_D} P_s(x) dx \right] \quad (3)$$

Equation 4 was initially proposed by Ohlendorf (Ref. 21) and is widely applied (Refs. 5, 22); it is also used in ISO 14179-2 (Ref. 3). The average friction coefficient is a function of load, roughness, lubricant viscosity, velocity and geometrical properties (Refs. 3, 6). The normal force distribution is assumed as described above. Together with Equations 2 and 3, the sliding power loss is deduced:

$$\bar{P}_s = H_v f_m P_{in} \quad (4)$$

Where P_{in} is the input power of the gear pairs and

$$H_v = \frac{\pi(i+1)}{z_1 i \cos(\beta)} (1 - \varepsilon_a + \varepsilon_1^2 + \varepsilon_2^2), \quad (5)$$

With i , ratio of the wheel and the pinion; z_1 , tooth number of the pinion; β , helical angle (0 for the spur gears); ε_a , profile contact ratio; ε_1 , ε_2 , tip contact ratio.

The instantaneous rolling frictional power loss is expressed as the product of the rolling velocity V_R and the rolling frictional force F_R , as in Equation 3.

$$P_R(x) = V_R(x) \cdot F_R(x) \quad (6)$$

However, power loss due to rolling is often neglected because the sliding power loss dominates the gear mesh losses.

Power losses due to oil churning. Modeling of power losses due to spinning gears is complicated, so most models in the literature are empirical, based on dimensional analysis. Mauz (Ref. 23) investigated various influencing factors like spinning direction, oil viscosity, housing effect and oil volume experimentally, and developed an equation to predict oil churning power losses:

$$T_{pl} = 1.86 \cdot 10^{-3} \cdot \left(\frac{\eta_{oil}}{\eta_0} \right)^{-1.255} \left(\frac{R_a}{R_0} \right) \cdot C_{WZ} \cdot C_{WA} \cdot C_M \cdot C_V \cdot \eta_{oil} \cdot v_t \cdot A_B, \quad (7)$$

With R_a , gear tip radius; C_{WZ} , C_{WA} , factor of distance from wall; C_M , factor of module; C_V , factor of oil volume; v_t , peripheral speed; A_B , gear immersion area.

Although a range of influence factors are considered in the model, many of the parameters are not available for the vehicle transmission test and the validity range of the model is also limited. Another model is employed in the ISO 14179-2 (Ref. 3):

$$T_H = C_{SP} C_1 e^{C_2 \left(\frac{V_T}{V_{T0}} \right)} \quad (8)$$

where C_{SP} , C_1 and C_2 depend on the parameters of the immersion depth of pinion and wheel.

Besides, many models from literature take the form of the model by Boness (Ref. 24).

$$T_{pl} = \frac{1}{2} \rho (1.1047n)^2 R_p^3 S_m C_m \quad (9)$$

With ρ , density of the lubricant; n , gear rotational speed; R_p , gear pitch radius; S_m , surface area of contact between the gear and the lubricant; C_m , dimensionless drag torque based on dimensional analysis.

Deduced from dimensional analysis, the corresponding expression of C_m depends on the flow regimes characterized by Reynolds and Froude numbers. Changenet (Ref. 25) characterizes additional regimes and broadens the range of application of dimensional analysis to helical gears. The dimensionless churning torque C_m is expressed in five groups — depending on speed factor γ and Reynolds number Re .

Bearing losses. It is difficult to directly model the load-dependent power losses and load-independent losses of bearings because there are different bearing types that vary in terms of geometry and design parameters. Therefore, the manufacturers (INA/FAG (Ref. 13) and SKF (Ref. 26)) provide empirical models to estimate the drag torques on the bearings that are widely applied in the literature.

According to INA/FAG, the drag torque of the bearing can be calculated through the following equation. It is also included in the ISO 14179-2 (Ref. 3):

$$T_{pl} = T_{B0} + T_{B1} \quad (10)$$

where T_{B0} is the load-independent bearing power losses and T_{B1} the load-dependent bearing power losses.

The SKF model is composed of four loss contributors to calculate the drag torque of a bearing, i.e. — rolling frictional torque T_{rr} ; sliding frictional torque T_{sl} ; drag torque of oil bath lubrication T_{drag} and frictional torque of the sealing T_{seal} .

$$T_{pl} = T_{rr} + T_{sl} + T_{drag} + T_{seal} \quad (11)$$

Simulation on a 2-Speed Transmission in an Electric Vehicle

As discussed earlier in this paper, there are different models to predict the component power losses inside a transmission, corresponding to the different loss sources in Equation 1; the combinations are therefore varied to calculate the overall power losses of the transmission. To compare the models, two sets of combinations are chosen here. One of them is to apply all of the models from ISO 14179-2. The other one is to combine the integration model for gear meshing losses, the model of Changenet for the oil churning losses, and the SKF model for bearing losses — referred to as the joint model.

A 2-speed, 2-stage transmission for an electric vehicle (Fig. 2) with a high-speed electric motor is selected for the case study. The ratio of the 1st gear is 21.83 and the ratio of the 2nd gear is 16.04. The center distance from the input shaft to the intermediate shaft is 69 mm, and the one from intermediate shaft to output shaft is 115 mm. Some gears are immersed in the oil, and there are only deep-groove ball bearings in the system; the experiment is conducted by an industry partner. The efficiency map of the transmission for the lower ratio was acquired at a stationary temperature of 100°C and with a

constant oil level on the test bench. There was no speed difference between the two out-put shafts, therefore no differential losses needed to be considered. The input torque varied from 3.6 Nm to 20 Nm, and the input speed varied from 1,000 rpm to 22,000 rpm.

The results of the two calculation methods are illustrated in Figure 3. In general, the joint model predicts a higher efficiency than the ISO 14179-2 methods. The largest difference is found in the low-input torque area. The efficiency calculated by the joint model (Fig. 3b) is 4.47% higher than predicted by ISO 14179-2 (Fig. 3a). Figure 4 shows a side-by-side comparison of the delta efficiency maps (measurement vs. calculation) for each method, and the results of the two methods vary considerably. A larger difference between the prediction

by ISO 14179-2 and the measurement (Fig. 4a) can be clearly observed, which ranges from 0.2% to 12.2%. In contrast, the difference between the prediction by the joint model and the measurement ranges from -2.1% to 4.0%. From the comparison, it can be concluded that the joint model provides a better overall efficiency prediction for the example transmission.

Parameter Identification Applied to the Joint Model

Even though the joint model shows a better agreement for the overall efficiency of the 2-speed transmission, there is still potential to improve the quality of the prediction. Parameter sensitivity studies were carried out for each loss type in the joint model. Based on the results of the parameter studies, several parameters from the models are selected, such as immersion depth, oil viscosity, gear surface roughness, correction factor for axial/radial forces on bearings and so on, and formed as the parameter vector. According to the models, the reasons that these parameters shall be identified are apparent. For example, the oil viscosity parameter plays a certain role in every model. The axial/radial forces on the bearing are deduced from the static analysis on the shaft at each input torque, which shall be corrected due to the deformation of the shaft at different torque input.

The parameter identification is applied to the joint model, with the help of the experimental data. The efficiency differences $\Delta\eta$ between measurement and calculation result by the joint model at corresponding transmission input torque and input speed are set as the criteria for optimization:

$$\Delta\eta = \left| 1 - \hat{\eta}(T_{in}, n_{in}) - \frac{P_V(T_{in}, n_{in})}{P_{in}(T_{in}, n_{in})} \right| \quad (12)$$

In Equation 12, $\hat{\eta}$ denotes the experiment data for the overall efficiency of the transmission at specific input torque T_{in} and input speed n_{in} . The trust-region method (Ref. 27) is employed to search the best-fitting parameter vector.

The boundary of the parameter vector is given according to different parameters' physical meaning and limitation. At end, the best fit parameter vector is identified (Fig. 5).

The identified parameters are put back in the joint model. In Figure 6, contour maps are used to illustrate how the parameter identification assists to minimize $\Delta\eta$. In the high-input torque area, as well as the high-input speed area, the difference between measurement and calculation is clearly decreased with the best-fit parameter set. The comparison in Figure 7 shows a power loss stack up comparison for a transmission input torque of 10 Nm. The overall power loss of the best-fit parameter set shows good agreement with the measurement. The change in the gear churning power loss appears to be the dominant factor in this case.

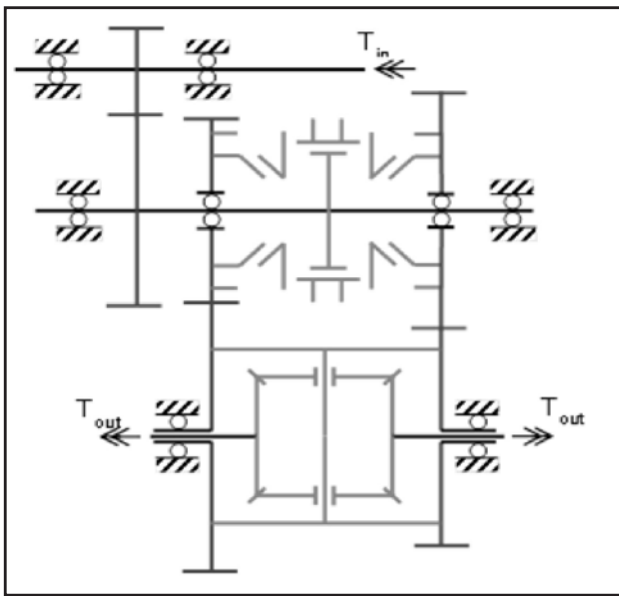


Figure 2 The structure of a 2-speed transmission in an electric vehicle.

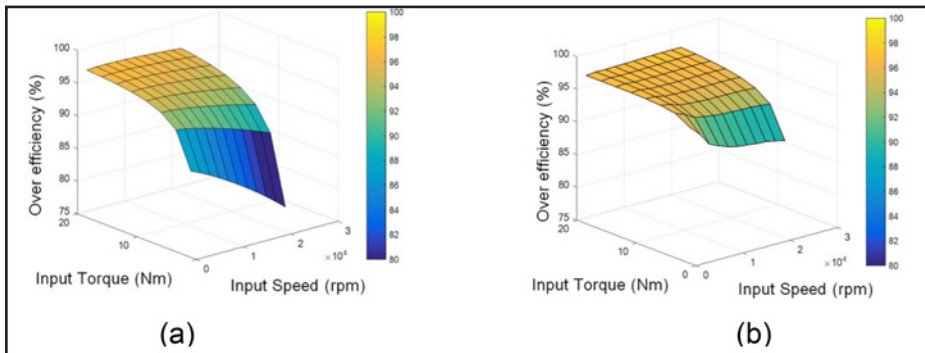


Figure 3 Comparison of the calculation results of (a) ISO 14179-2 and (b) the joint model.

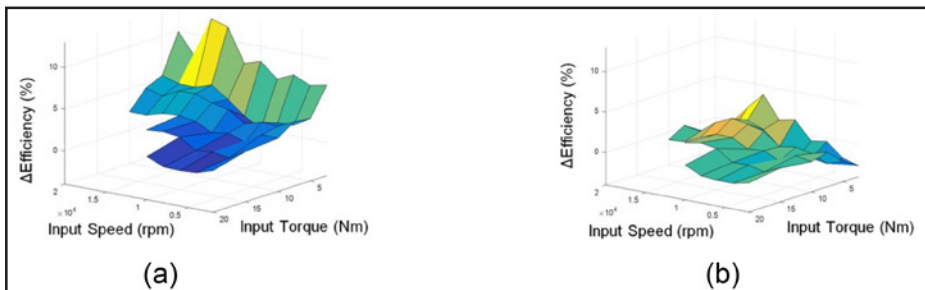


Figure 4 Comparison to the measurement with the calculation by (a) ISO 14179-2 and (b) the joint model.

The best-fit parameter set provided a better agreement between the measurement and the joint model than the initial parameter set. In this way, it was also possible to analyze which components inside the transmission contribute to which extent. Thus the target to compare and assess different transmission products in detail is realized. In addition, it is also possible to search for the optimization potential inside the transmission assisted by the identified parameters.

Conclusion and Perspective

In this paper, the models for different power loss sources in transmissions from literature are applied and compared, which form the two methods—ISO 14179-2 and the joint model to estimate the power losses in a transmission. A 2-speed transmission in an electric vehicle is used as a case study to compare the two methods and validate them with experimental data. Parameter identification is carried out on the selected model, and the overall efficiency of the transmission calculated by the joint model agrees better with the measurement. Using this process, a better understanding of the breakdown of losses inside a transmission is gained; it is then possible to further improve the overall transmission efficiency. In the future, more models to predict other component power losses in the transmission will be investigated and added in the joint model. More transmission types are expected to be studied and compared. **PTE**

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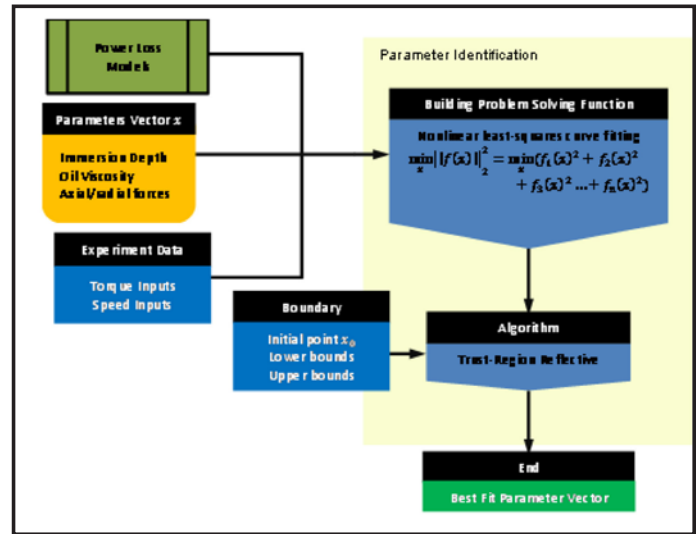


Figure 5 The process of parameter identification for the joint model.

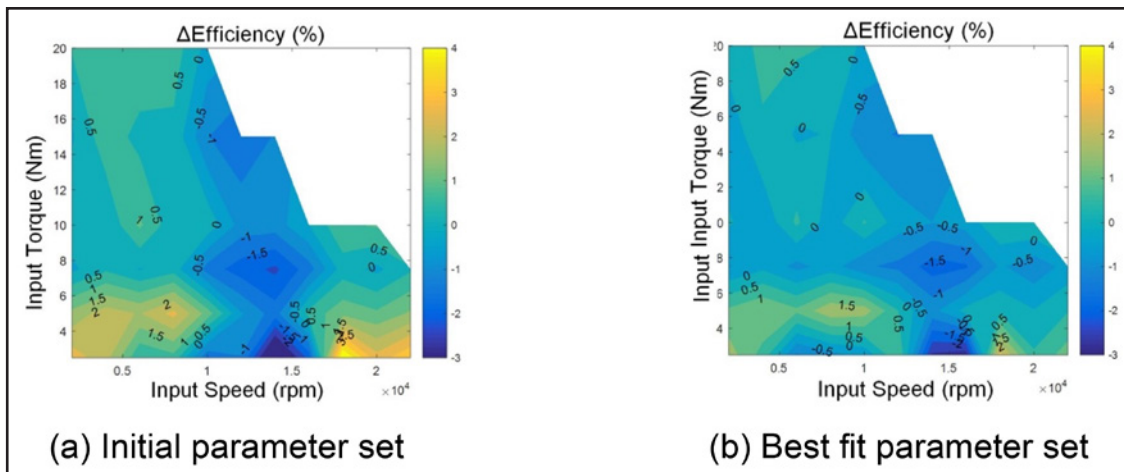


Figure 6 Comparison of $\Delta\eta$ before and after parameter identification.

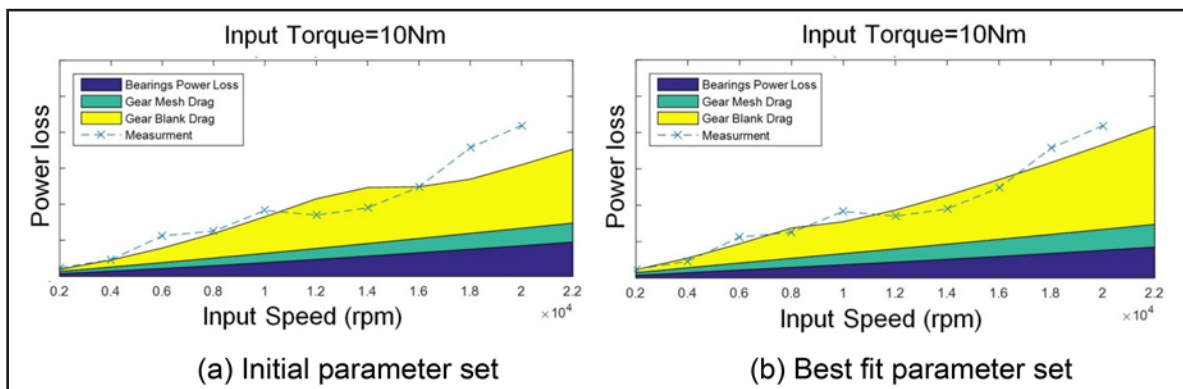


Figure 7 Segment power losses before and after parameter identification.

References

- Ernst, C. S., L. Eckstein, and I. Olschewski. "CO₂-Reduzierungspotenziale bei Pkw bis 2020," Abschlussbericht Dezember (2012).
- Sedlmair, M.; J. Geiger, J-P. Stemplinger and K. Stahl. "Efficiency Potential of a Manual Transmission: Simulation of Optimization Measures in Gears and Lubricants," *15th Intern. VDI-Congress Drivetrain for Vehicles*.
- ISO, BS. "TR 14179-2: 2001 Gear Thermal capacity, Part 2: Thermal Load Carrying Capacity," (2001).
- Fernandes, C., et al. "Gearbox Power Loss, Part III: Application to a Parallel Axis and a Planetary Gearbox," *Tribology International* 88 (2015): 317-326.
- Rosander, P., et al. "Entwicklung eines Wirkungsgrad-modells für Schaltgetriebe," *ATZ-Automobiltechnische Zeitschrift* 110.4 (2008): 346-357.
- Niemann, G. and H. Winter. *Maschinenelemente Band 2*, Springer Verlag, 2, Auflage, 2003.
- Anderson, N. E. and S. H. Loewenthal. "Design of Spur Gears for Improved Efficiency," *Journal of Mechanical Design* 104.4 (1982): 767-774.
- Anderson, N. E. and S.H. Loewenthal. "Spur-Gear-System Efficiency at Part and Full Load," National Aeronautics and Space Administration, Cleveland, Ohio, Lewis Research Center, 1980.
- Petry-Johnson, Travis T., et al. "An Experimental Investigation of Spur Gear Efficiency," *Journal of Mechanical Design* 130.6 (2008): 062601.
- Mauz, W. *Hydraulische Verluste von Stirnradgetrieben bei Umfangsgeschwindigkeiten bis 60m/s*. Universität Stuttgart 1987.
- Changenet, C. and P. Velex. "A Model for the Prediction of Churning Losses in Geared Transmissions—Preliminary Results," *Journal of Mechanical Design* 129.1 (2007): 128-133.
- Seetharaman, S. and A. Kahraman. "A Windage Power Loss Model for Spur Gear Pairs," *Tribology Transactions* 53.4 (2010): 473-484.
- SKF GmbH (Schweinfurt). SKF-Hauptkatalog: das Wälzlager-Handbuch für Studenten; [Katalog 5000 G], 2004.
- Schaeffler Gruppe, INA/FAG Wälzlagerkatalog, January 2006.
- Simrit: Radialwellendichtringe, Katalog Nr. 100 (1976).
- ISO, BS. "TR 14179-1: 2001 Gear Thermal Capacity Part 1: Thermal Load Carrying Capacity," (2001).
- Drozdov, Y. N. and Y.A. Gavrikov. "Friction and Scoring under the Conditions of Simultaneous Rolling and Sliding of Bodies," *Wear*, pp. 291-302, 1967.
- O'Donoghue, J. P. and A. Cameron. "Friction and Temperature in Rolling Sliding Contacts," *ASLE Transactions* 9, pp. 186-194, 1966.
- Kelley, B. W. and A.J. Lemanski. "Lubrication of Involute Gearing," *Proc. Instn. Mech. Engrs*, Vol. 182, pp.173-184, 1967-1968.
- Xu, H. "Development of a Generalized Mechanical Efficiency Prediction Methodology for Gear Pairs," Diss. The Ohio State University, 2005.
- Ohlendorf, H. *Verlustleistung und Erwärmung von Stirnrädern*, Dissertation, TU München 1958.
- Fernandes, C. et al. "Gearbox Power Loss, Part II: Friction Losses in Gears," *Tribology International* 88 (2015): 309-316.
- Mauz, W. "Hydraulische Verluste von Stirnradgetrieben bei Umfangsgeschwindigkeiten bis 60m/s," Dissertation, Universität Stuttgart, 1988.
- Boness, R. J. 1989, "Churning Losses of Discs and Gears Running Partially Submerged in Oil," *Proc. ASME Int. Power Trans. Gearing Conf.*, Chicago, Vol. 1.
- Changenet, C. and P. Velex. "A Model for the Prediction of Churning Losses in Geared Transmissions—Preliminary Results," *Journal of Mechanical Design* 129.1 (2007): 128-133.
- Schaeffler Gruppe, INA/FAG Wälzlagerkatalog, 2008.
- Conn, A. R., N. Gould and P. L. Toint. "Trust Region Methods," *Society for Industrial and Applied Mathematics*, 2000.

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Validation Approach of PM Gears for e-Drive Applications

Björn Leupold, Vitali Janzen, Dr. Gerd Kotthoff, Dominic Eichholz

Introduction

Key technical drivers which can be addressed by advanced PM manufacturing technologies are, for example, the need for system downsizing in transmissions and differentials, the need for developing systems with higher power density and the strong NVH (Noise Vibration Harshness) requirements—especially for electrified transmissions or e-axle solutions. In the case of making use of sintered gears in highly loaded applications like automotive transmissions, advanced net shape compaction technology can be applied to produce gears with helix angle above $\beta = 30^\circ$. However, the residual porosity at conventionally pressed and sintered gears requires further density/performance increasing measures. Surface densification technology by transverse rolling is today well known and can be used to increase the density, primarily in the highest loaded volume of the gear teeth, while powder forging technology creates a fully dense component (Refs. 1–4). For surface densification technology, within recent years a strong move from basic research on process simulation (Refs. 5–7) and performance data generation (Refs. 8–11) towards demonstrator applications and PM gear validations on transmissions (Refs. 12–14) could be observed.

This paper gives an overview of the described process technologies and the exemplary results in the case of performance and NVH behavior; the adaption of the surface densification technology for e-drive applications including testing will be shown. Last, but not least, the successful validation of an e-drive gearbox with a PM intermediate gear is the main outcome of this work.

PM Process Routings

Compared to the standard PM process routings for gear production, only routings for highly loaded PM gears—characterized by different density-increasing measures—are de-

scribed. Especially surface densification by transverse gear rolling and forging powder metal (FPM), both part of GKN's PM process portfolio, are known as the two most important technologies to produce highly loaded PM gears (Fig. 1).

The surface densification (gear rolling) process route starts with the powder manufacture, followed by compaction and sintering of a gear pre-form and a transverse rolling process. Depending on the strength requirements of the gear, different sintered (core) densities can be provided. As dictated by the product application, heat treatment of the surface-densified gears may be required after rolling. If carburizing is applied, the process chosen must consider the specific carburizing behavior of a surface-densified gear (Ref. 5) and, depending on the gear quality requirements, hard finishing like gear grinding or gear honing may be necessary after heat treatment. The forged powder metal (FPM) route creates a fully dense gear product from a compacted and sintered PM pre-form. The single-stroke, hot forging process shapes the component to its forged contour and generates a new metal matrix by metal particle shearing through material flow.

Design Approach and Testing

When driving a customer request for a high-performance PM gear to an engineered product, close collaboration between supplier and customer is crucial. Starting with a drawing and loading situation analysis of the gear application, PM material and process routings are defined. While for gear load calculations conventional design tools like *KissSoft* are used, both for gear rolling and forging powder metal gears unique software solutions have been developed, or existing software codes have been modified to optimize the predictive design tasks for surface densified gears (Ref. 12). In particular, the GKN proprietary software *KinSim* allows modeling of the fi-

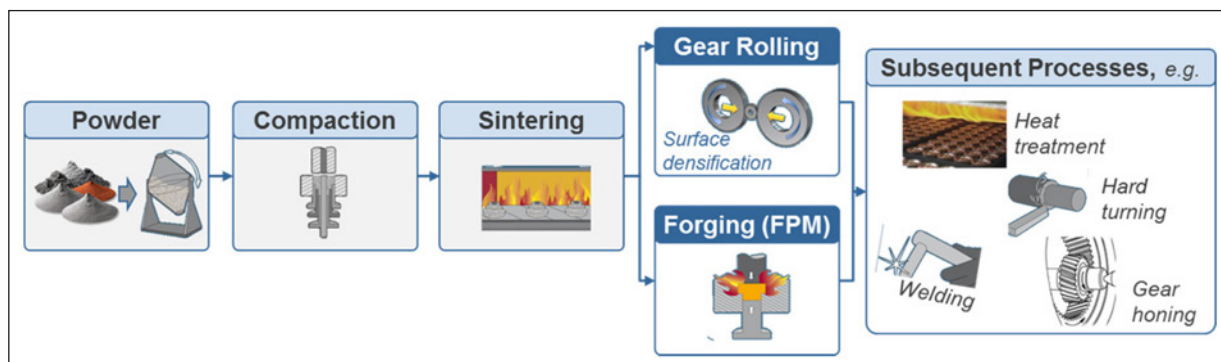


Figure 1 Process routings for high-performance PM gears.

nal shape and pre-form shape of the PM gear, the rolling tool shape, and to feed the proprietary-developed predictive FEA tools for the surface densification process (Fig. 2).

As shown (Fig. 2) for rolled gears, in-house-developed FEA tools allow prediction of both the expected density profile as well as the shape of the tooth flank after the rolling process and, therefore, to shorten the development time for the gear pre-form and rolling tool design.

As an initial guideline for selecting the best PM processing route for a given application, GKN has created a gear performance guideline (Fig. 3).

The (Fig. 3) graph builds on tooth flank and tooth root performance tests of sintered gears, and compares the

performance values to a case hardened 16MnCr5 reference. With this, a first selection of a PM process and density level for a given gear loading condition can be done without having detailed PM process knowledge.

Furthermore, GKN has developed the “GSM test gear” geometry as a standard test gear for all in-house-available PM process routings, i.e. — standard PM, rolled and forged powder metal (FPM) gears (Refs. 10, 12). Within an ongoing testing program, production tools for all PM processes (incl. rolling/forging) are available. To clearly focus on the performance of the different materials and PM manufacturing routes, test gears are hard finished by profile grinding (Q5, DIN) to a comparable quality and surface structure. For

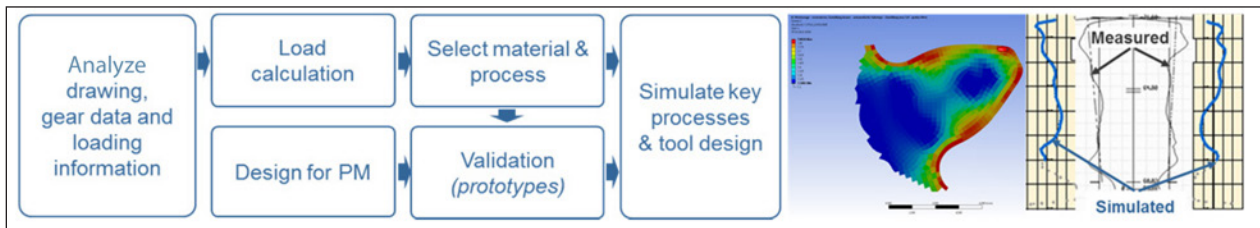


Figure 2 Design approach and state-of-the-art simulation for rolled gears.

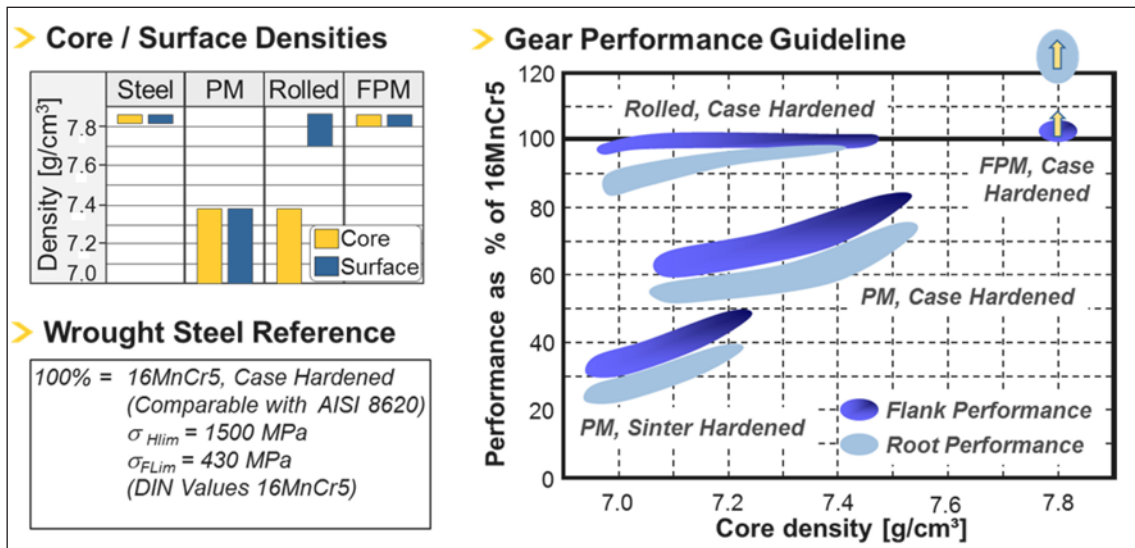


Figure 3 Gear performance map for PM gears compared to wrought steel gears.

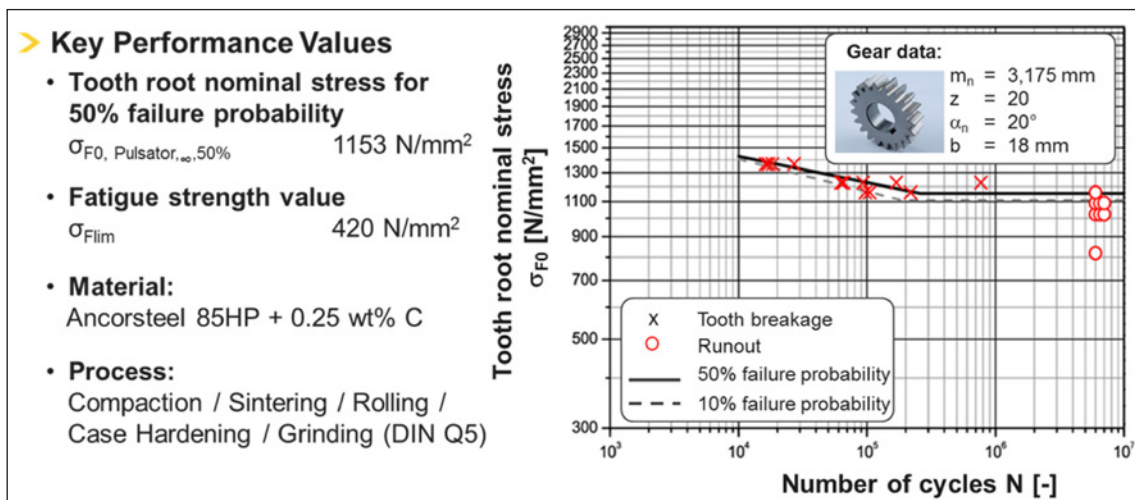


Figure 4 Tooth root strength S/N curve of a surface-densified gear.

investigation of tooth root performance, a resonance pulsator is used; for the flank performance tests an FZG back-to-back test rig is used according to DIN ISO 14635. The endurance limit for tooth root tests is 3 mio. cycles; for the pitting tests it is 50 mio. cycles. At the end of both test methods S/N curves are generated.

A typical data set of a tooth root performance test of surface densified and case hardened PM gears made of Ancorsteel 85 HP (Fe-0,85Mo)+0.25%C with a tooth root bending stress of 1153 MPa (50% failure probability) is shown (Fig. 4).

Motivation to Apply Surface Densification for e-Drive Applications

Recently, a fourth speed and $\beta = 34^\circ$ helical manual transmission gear have been developed completely off-tool towards series production—including the whole package of required, successful customer validation tests focusing on further improvement of rolled gear quality at high helix angles with a tailored heat treatment and gear honing (Refs. 12, 14).

The product shows a high quality before the heat treatment, including the protuberance that is needed for the power-honing process. Some of the key test procedures are shown (Fig. 5).

For gear durability, three out of three tests passed the test criteria, including one test with increased load and longer

run times than expected. At the end of the durability test, no wear at all could be detected at the tooth flanks and the profile was comparable to the known profile of the steel gear reference.

How to Apply for e-Drive Applications

Due to the strong move away from the internal combustion engine and conventional transmissions towards electrified drivetrains, future electrified transmissions are also a crucial element of our gear strategy at GKN. Motivated by the positive results of the transmission gears, the engineering team was looking for a more challenging application for PM gears within those areas. Knowing that GKN Driveline is an established development partner for high-performance, electric driveline systems with more than 300,000 electric axle drives produced to date, the GKN powder metallurgy engineers strongly believed that PM technology can make the difference in the future mobile world, being able to provide significant benefits.

The cross-divisional engineering team decided to build the first technical demonstrator of an e-transmission with “PM inside” and to validate the system related to performance and NVH in an already-existing series production, high-performance GKN e-drive gearbox (Fig. 6).

The intermediate gear made of conventional case hardening steel was replaced by a PM gear with a core density

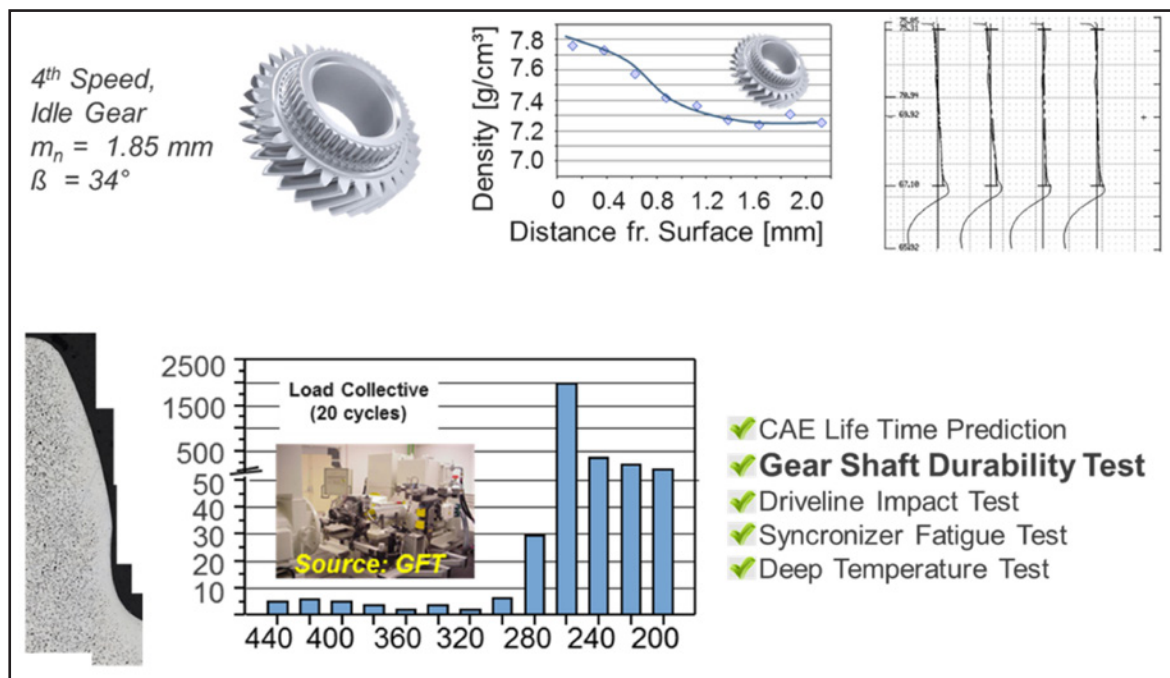


Figure 5 Successful validation of surface-densified transmission gear, $\beta = 34^\circ$.

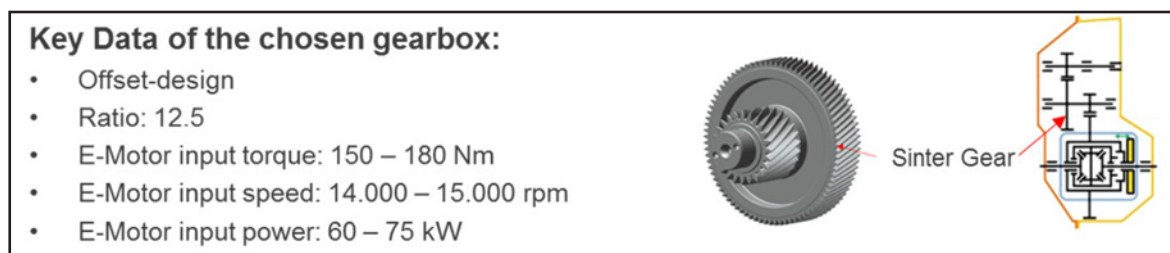
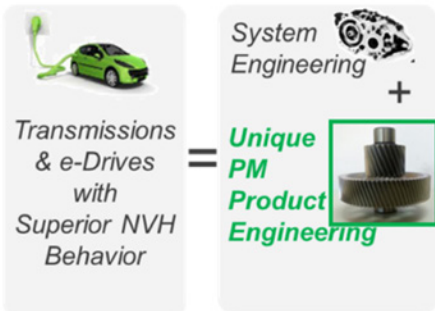


Figure 6 Sinter gear in e-drive gearbox.

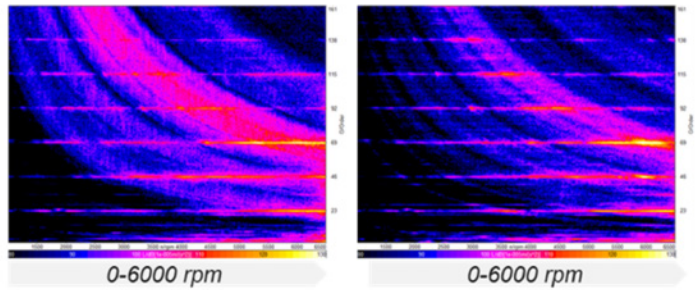
> Engineering Approach



NVH test:
A/B Comparison at eDrive Gear Box
PM Gear vs. Steel Gear



> Order Analysis (Steel Gear Left, PM Gear Right)



> Averaged Selective Analysis 1st to 5th Orders

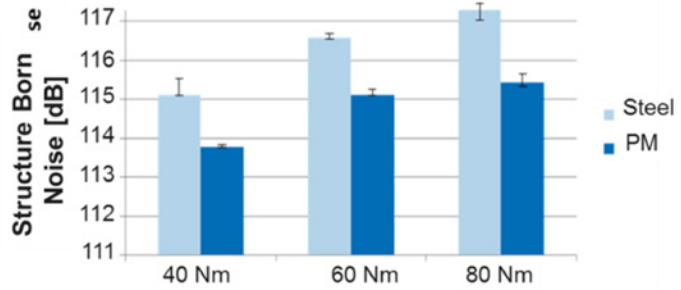


Figure 7 Case study, e-drive gear — NVH A/B comparison.

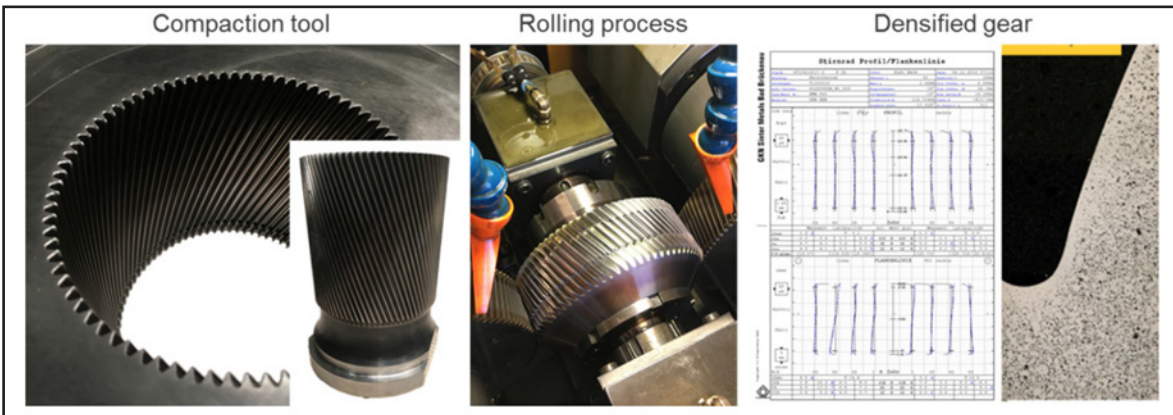


Figure 8 Manufacturing of off-tool parts.

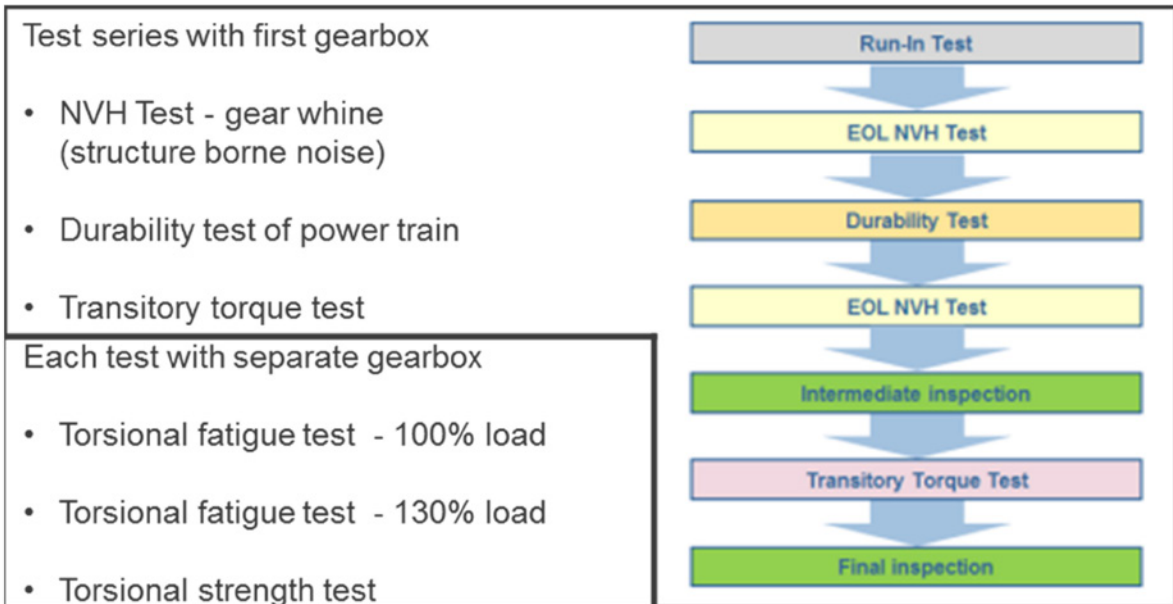


Figure 9 Test and validation program of e-drive gears.

of 6.8 g/cm^3 , assuming a positive influence from the porosity on the NVH behavior. Hard finishing of the PM gears was identical to the wrought steel version to make sure that profile and lead modification — as well as surface structure — are comparable and only the material and density influence on the NVH behavior could be evaluated. For the investigation, the gearbox has been assembled on an NVH test bench. Test runs have been carried out at three torque levels (40, 60 and 80 Nm) at rotational speeds up to 6,000 rpm, which is comparable to speeds of up to 50 km/h (city mode). Figure 7 shows the result of the A/B structure-borne noise comparison represented by the Campbell diagrams for the steel and PM gear (top right), and the averaged selective analysis for the 1st to 5th orders (Ref. 15).

It is evident from the figures that the PM gears with an overall density of 6.8 g/cm^3 show a significant difference in the NVH behavior, and Eigen frequencies are influenced based on the change in material and porosity. Depending on the rotational speed and torque, up to 3 dB lower structure-borne noise could be realized.

Off-Tool Gear Manufacturing and System Validation

Knowing that the performance requirements for this type of transmission gear require surface densification, further investigations of the performance and NVH behavior were car-

ried out. For this, the complete PM process chain was worked on, starting with the material, the compaction of net-shaped parts to a slightly increased density of 7.1 g/cm^3 , sintering and surface densification. Heat treatment and hard finishing processes have been carried out under serial conditions at GKN Driveline. In the first step, tip relief and crowning are identical to the steel design, knowing that adaptations for the PM design will be needed.

Having the gears produced, a typical GKN Driveline validation program was used to test the parts. The target was that the sintered gears had to pass all tests with same or better performance compared to wrought steel gears; the test program is shown (Fig. 9).

For the NVH test, different high-speed and high-torque steps had to be passed with the structure-borne noise level not higher than customer requirements. After the positive passing of this test the durability test of the powertrain and the transitory torque test were done with the same gearbox.

The durability test (Fig. 10) consists of different steps (high torque with low speed; medium torque with medium speed; low torque with high speed) in a *Multi-Block-Program (MBP)*. The *MBP* is a condensed program for a defined number of hours that presents the gear damage of a gearbox lifetime. After finishing 100% of the *MBP*, full torque transmission is required, with 20% pitting on teeth surface allowed, but no initial cracks or breaks.

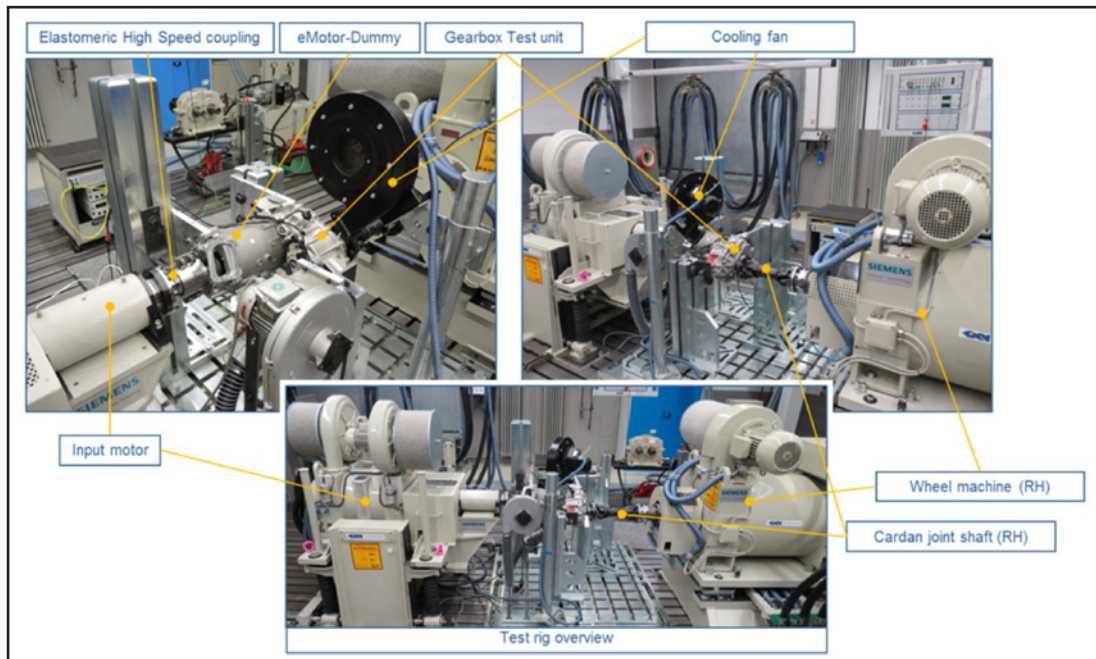


Figure 10 Typical test rig set-up of durability test.

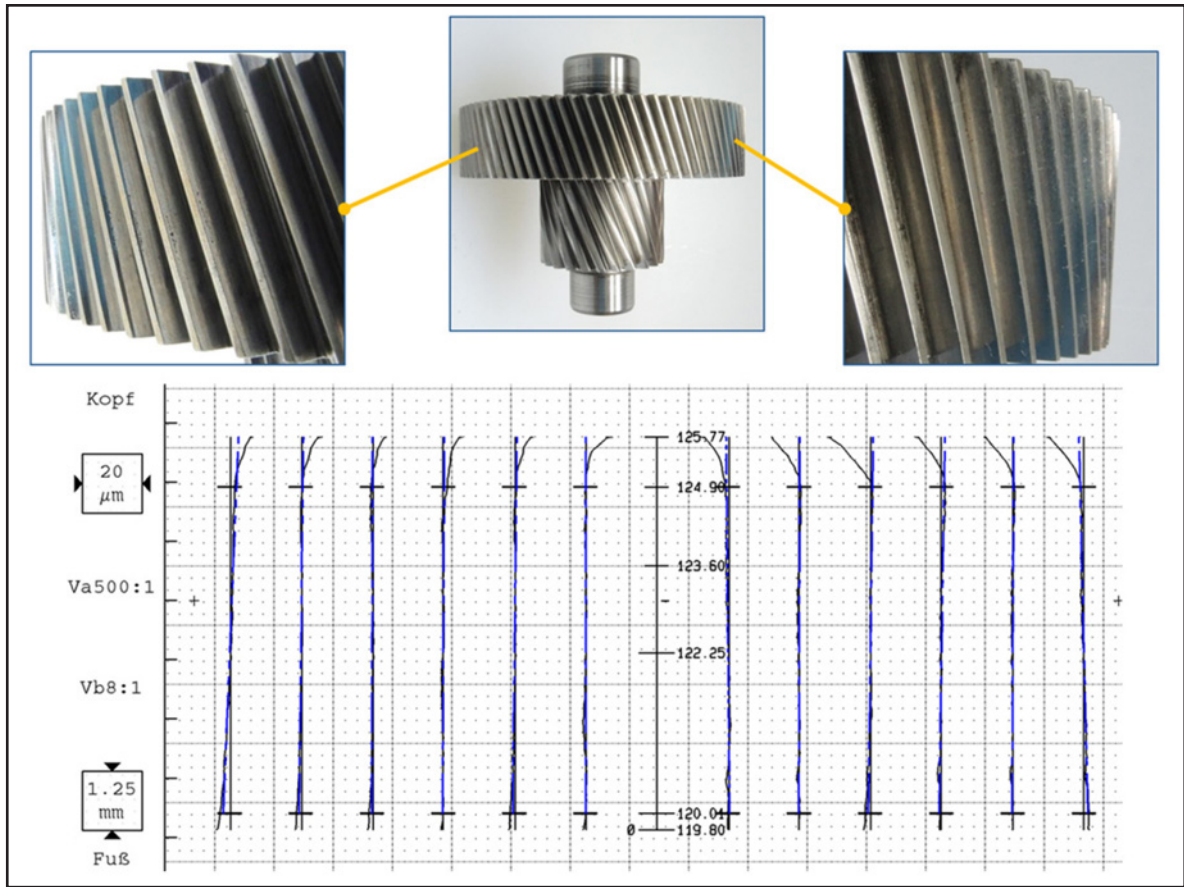


Figure 11 Sinter gear after durability test.

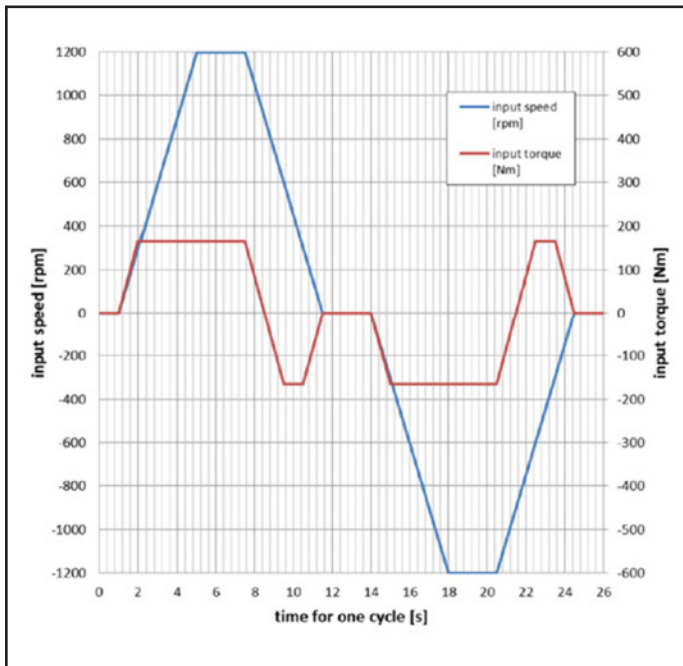


Figure 12 Alternating load under revolutions.



Figure 13 Sinter gear after torsional strength test.

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During the last test with this gearbox an alternating load with frequency 0.5 Hz was put on one tooth flank with double the nominal load and customer-agreed number of cycles. No initial cracks or breaks are allowed. All three tests were passed with the same gearbox; the wear was within the specification (Fig. 11).

The torsional fatigue tests (Fig. 12) with alternating loads of 100% and 130% of the nominal torque with a defined number of cycles were passed with two additional gearboxes without initial cracks or breaks.

The last step within the validation program was the torsional strength test, where the torque was increased (twist angle at gearbox output shaft: 15°/minute) on a blocked gearbox until one component of the system failed, which was *not* the PM intermediate gear (Fig. 13).

As an overall test summary, it can be stated that the PM intermediate gear in the e-drive gearbox passed all steps in the required validation program. Regarding strength, wear and NVH performance, the sinter gear is at the same level as the replaced steel gear.

Outlook

It was shown that the holistic approach for design and performance positions PM technology with the potential to be used in e-drive applications. GKN continues to work on different optimizations in order to further increase the benefits in the area of the NVH behavior in comparison to wrought steel gears. First simulations with a new FEA-based modeling approach indicate that the excitations of a surface-densified PM gear can be further optimized by applying a tailored microgeometry. Along with validation tests to confirm the model-based approach, further tests on gears with optimized gear bodies are planned and will help to build an even stronger basis and design guide for the product and application engineers. **PTE**

Questions or comments regarding this paper? Contact Bjoern Leupold at bjoern.leupold@gknpm.com.

References

1. Heuler, P., B. James, R. Lawcock, H. Schulz, M. Strömgen and R. Wonneberger, "The Use of Powder Metallurgy for Load Bearing Applications such as Gears," R&D Report, German Federal Ministry of Education and Research (BMFT), Dec. 1988, Report-No. TF-2608 (COST 503).
2. James, B.A. "The Production of Gears for Highly Stressed Applications by Powder Metallurgy," Internal R&D report No. 1959, Jan. 1990, Part I + II, GKN Technology Ltd.
3. König, W., K. Vossen, G. Röber and M. Strömgen. "Powder Forging of Helical Gears for Passenger Car Manual Gearboxes - Modern Developments in Powder Metallurgy," *Proc. of the International P/M Conference* Orlando, MPIF/APMI, Princeton, NJ, Jun. 5-10, 1988, Vol. 18, pp. 253-268.
4. Jones, P.K. and J. W. Wisker. "The Production of Precision Automotive Components by the Powder Forging Process - Present Situation and Future Prospects," *Proc. of Soc. Automotive Engineers Congress* Detroit, Warrendale, PA, 1978, Technical Paper 780361.
5. Kotthoff, G. "Neue Verfahren zur Tragfähigkeitssteigerung von gesinterten Zahnradern," 2003, Ph.D. Thesis, Technical University Aachen, Germany.
6. Kauffmann, P. "Walzen Pulvermetallurgischer Zahnäder," 2012, Ph.D. Thesis, Technical University Aachen, Germany.
7. Gräser, E. "Materialfluss beim Dichtwalzen," 2015, Ph.D. Thesis, Technical University Aachen, Germany.
8. Klocke, F., C. Gorgels, E. Gräser, P. Kauffmann, T. Zundel, G. Kotthoff and F. Wattenberg, "PM Gear Testing," *Proc. of PM World Congress* Florence, European Powder Metallurgy Association, Shrewsbury, UK, 2010, ISBN 978-1-899072-12-5, Vol.3, p. 317-326.
9. Andersson, M. "Optimizing the Tooth Root Strength of Sintered Gears for a Manual Automotive Transmission," *Proc. of Euro PM Gothenburg*, European Powder Metallurgy Association, Shrewsbury, UK, 2013, Vol 2, p. 97-102.
10. Leupold, B. "Reliable Performance Data for PM gears - A Holistic Approach," *Proc. of Euro PM Salzburg*, European Powder Metallurgy Association, Shrewsbury, UK, 2014.
11. Leupold, B. "PM Automotive Gears with Tailored Performance," *Proc. of World PM Hamburg*, European Powder Metallurgy Association, Shrewsbury, UK, 2016.
12. Kotthoff, G. "High-Performance PM Gears - Status and Opportunities," *Int. Conference on Powder Metallurgy* Chicago, Metal Powder Industries Federation, Princeton, NJ, 2013, Presentation at Special Interest Session.
13. Powder Metal Gearbox Initiative. "World's First Powder Metal 6-speed Manual Transmission on Display," Press Release and Booth at VDI Drivetrain in Vehicles Conference Friedrichshafen, VDI Verlag Düsseldorf, Germany 2015.
14. Steinert, J. "Technical and Economical Viability of Surface Rolled PM Gears for Manual Car Transmission," *Proc. of Euro PM Reims*, European Powder Metallurgy Association, Shrewsbury, UK, 2015.
15. Kotthoff, G. and A. Zeller. "Innovative PM Gear Technology for Transmission and Drivetrain Systems," *Proc. of 5th International CTI Symposium* China, Shanghai, 2016.

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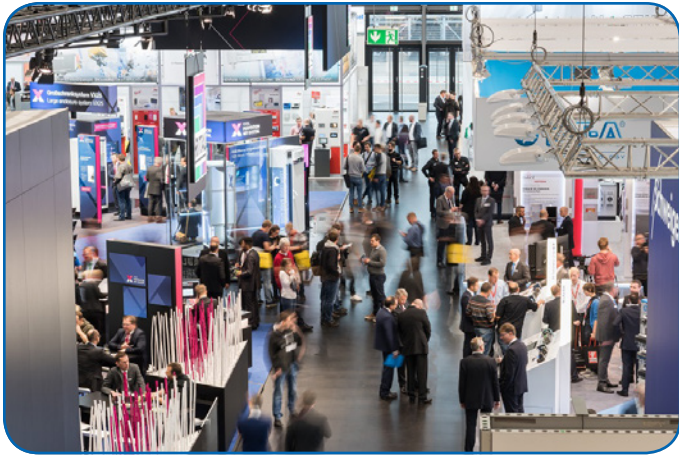
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SPS Smart Production Solutions

CELEBRATES 30 YEARS

Despite the challenging economic climate ahead of the SPS anniversary exhibition, the outlook for the trade show is once again very positive and testifies to the importance of the exhibition for smart and digital automation. Some 1,650 automation technology providers from all over the world are expected as exhibitors in Nuremberg from November 26–28, 2019. The exhibition will showcase current products and solutions in industrial automation as well as trend-setting technologies of the future.



Exhibition visitors will benefit from the wide range of products and services offered by national and international automation and digitalization providers, and within one day will still be able to gain a complete overview of the market. This explains why 71% of the visitors recorded by exhibition organizer Mesago to the automation trade show are day-visitors. 7% of visitors conduct their technology research over the full three days of the event. Last year, 27.6% (18,154) of the visitors came from outside of Germany. 47,546 of the previous year's visitors came from within the country. The positive impressions from the trade show were shared by these visitors:

“For me, the SPS is the best trade show around — a must for anyone working in automation technology,” commented Wolfgang Lex, technology and maker project manager at Conrad Electronic SE.

“The SPS is the highlight of the exhibition year for me. It acts as a beacon for the automation industry. Pooling automation and IT supports the journey to digitalization. At the event we really meet all the decision-makers from automation technology. The exhibition is invaluable for us,” Lorenz Arnold, managing partner, MGA Ingenieurdienstleistungen GmbH.

Digitization is having a major impact on the automation industry. Exhibitors will therefore present not only their solutions, but also various products and example applications for digital transformation at the event. IT providers are also increasingly represented at the SPS. The appeal is the strong emphasis on presenting the IT topics in cooperation

with the automation companies. Topics such as big data, cloud technology, 5G and artificial intelligence are often presented jointly with automation providers with practical examples and demos. In addition, topic-related showcases and presentations at the exhibition forums help to illustrate digital transformation in the manufacturing industry.

This year, the guided tours once again offer visitors from Germany and abroad the opportunity to visit innovative exhibitors for a concise overview of specific topics, including machine learning and AI, product and machine simulation, industrial security in production, cloud ecosystems and predictive maintenance. The focus of the tours is on real use cases.

Attendees can also obtain extensive insights into specific topics and ask providers for advice on their particular requirements at the joint booths:

“Automation meets IT”, (Hall 6)

“AMA Center for Sensors and Measurement”, (Hall 4A)

In addition, the forums to be held by the German industry associations VDMA (Hall 5) and ZVEI (Hall 6), as well as the exhibition forums (Halls 3 and 10.1), will offer high-quality, topic-specific presentations and podium discussions. There, attendees can learn more about the latest industry subjects and share their thoughts with the experts on hand.

For anyone interested in more in-depth information about current automation topics, the Congress that accompanies the SPS and organized by WEKA Fachmedien is ideal. In practice-based sessions of 4 hours' duration, this year will see a focus on the topics: 5G, TSN, and OPC UA in industrial environments, securely connected — from the sensor to the cloud, IoT Platforms — best practices, and flexible automation for little money — what does robotics offer?

As of 2019, SPS IPC Drives has a new name: SPS — Smart Production Solutions. While the title of this exhibition may have changed since its inception thirty years ago, the proven concept and areas of focus will stay the same and continue into the future. In this way, event organizer Mesago Messe Frankfurt GmbH, is taking the digital transformation of the industry into consideration while continuing to promise relevance, expertise, and exchange on equal terms. (*spsexhibition.com*)

Beckhoff Automation

HIRES PACKAGING INDUSTRY
MANAGER

Beckhoff Automation LLC hired **Mark Ruberg** as packaging industry manager to further strengthen its presence among U.S. packaging and processing OEMs and manufacturers of consumer-packaged goods (CPGs). Drawing on impressive packaging industry experience and leadership skills, Ruberg will oversee sales efforts and application support for new and



existing Beckhoff customers focused on the packaging and processing of goods across the U.S. Ruberg is joining Beckhoff at an opportune time, as the company has accelerated the introduction of automation technologies for packaging applications in recent years, most notably with the mechatronic eXtended Transport System (XTS).

Ruberg's experience in packaging and plastics most recently involves serving as a regional sales manager for Conair Group, Inc. His resume also includes seven years at packaging machinery company ProMach, Inc., first as director of corporate business collaboration, then vice president of ProMach Business Process and finally overseeing business development of ProMach's productivity software, ZPI. Ruberg previously spent 15 years at plastics machine builder Milacron, where he started as a sales engineer and ended as managing director for the Americas.

With the hiring of Ruberg, the previous packaging industry manager, Joe Martin, can focus exclusively on his role as west region manager.

"We are excited to harness the extensive packaging industry knowledge that Mark brings to Beckhoff," said Kevin Barker, president of Beckhoff Automation LLC. "Mark has been an active member of the Packaging Machinery Manufacturing Institute (PMMI), serving on their Global Marketing Committee and several of their OpX work groups. He has served on the global board of directors for the Organization for Machine Automation and Control (OMAC) and participated in updating and promoting the PackML standard. As a champion of EtherCAT and PC-based automation technology, Mark will be a great asset to our team moving forward."

Ruberg holds a bachelor's degree in physics from Thomas More College and a master of science in mechanical engineering from University of Cincinnati. He also founded and serves as director for the nonprofit O2 Urban Farms, which builds aquaponics farms to provide fresh produce and year-round job opportunities to people living in food deserts.

(www.beckhoffautomation.com)

United Stars

HIRES MCKERNIN AS GEAR GROUP SALES AND MARKETING DIRECTOR

United Stars, Inc. recently announced the appointment of **Michael McKernin** as the gear group sales and marketing director. With 35 years in the gear industry, McKernin brings experience in all aspects of gear engineering, manufacturing and sales. He will lead the value-added strategy to continue customer relations, offer solutions and products along with broadening the end-user markets and industrial applications.



With a degree in Manufacturing Engineering Technology from Bradley University, McKernin has been involved in all aspects of gear manufacturing, from machine tool operation

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to corporate management—including being the president at his previous company. McKernin currently serves as the chairman of the Business Management Executive Committee (BMEC) for the American Gear Manufacturers Association (AGMA) where he oversees the managerial and educational programs along with committee activity for AGMA members in manufacturing.

“I look forward to working with the great people at United Stars,” McKernin said. “The company vision and quality products coupled with my experience in the industry, will make a great team.”

United Stars, Inc. created this new positive for McKernin to increase opportunities and expand growth for the three gear companies currently in the United Stars, Inc. corporate holdings.

“Having Mike join our team is going to push our products even further,” said Richard Van Lanen, president of United Stars, Inc. “His passion for the industry and unparalleled customer service skills will help to grow our brand and the customer base we currently have.” (www.ustars.com)

Heidenhain

OPENS CENTRAL U.S. SALES OFFICE



Heidenhain announces the opening of a new central U.S. sales office as part of the company’s continued North American expansion efforts. Operating in Longmont, CO, this new office now provides direct sales support for central U.S. and Mexico territories, previously managed in either Heidenhain’s longtime Illinois or its 2017-established California headquarters.

“This new development allows Heidenhain to get even closer to our customers and is simply an extension of our ‘Customer First’ initiatives,” said John Thormodsgard, Heidenhain’s sales director for the central region. “The Longmont location is centrally located near Denver, Boulder and Fort Collins—a growing R&D, industrial and higher educational corridor—which we can now more efficiently support with our motion control technology expertise.”

Besides sales office space, Heidenhain’s new location can also host visitors in conference rooms as needed. The new office is located at 1079 S. Hover in Longmont, CO. Direct phone is 847-519-3988. (www.heidenhain.us)

Velodyne Lidar

SUPPLIES SENSORS FOR OPTIMUS RIDE

Velodyne Lidar, Inc. recently announced that Optimus Ride will use Velodyne’s lidar sensors in its entire fleet of self-driving vehicles. The sensors provide rich computer perception data that enables real-time object and free space detection for safe navigation and reliable operation. Optimus Ride, a leading self-driving vehicle technology company on a mission to transform mobility, will soon be operating its self-driving systems in four U.S. states.



“Velodyne’s sensors provide powerful lidar solutions that help us ensure our self-driving vehicles are the smartest and safest on the road today,” said Dr. Ryan Chin, Optimus Ride’s CEO and co-founder. “For Optimus Ride to operate a fleet at SAE Level 4 requires significant sophistication, intelligence, range and resolution. Velodyne’s technology meets these high standards.”

Optimus Ride operates self-driving vehicles that provide passenger transportation at low speeds within defined, geofenced areas such as planned communities, campuses, and self-driving zones in cities. The company’s vehicles are currently deployed in Boston’s Seaport District, South Weymouth, Mass and at the Brooklyn Navy Yard in Brooklyn, New York. Optimus Ride’s deployment in the Navy Yard is the first commercial deployment of self-driving vehicles in the state of New York. Optimus Ride will soon deploy at Paradise Valley Estates in Fairfield, Calif. and Brookfield Properties’ Halley Rise development in Reston, Va.

Using Velodyne sensors, Optimus Ride can precisely locate the position of people and objects around its vehicles, as well as calculate their speed and trajectory. With that information, the vehicle’s on-board computer system determines how to drive to its destination.

“The Optimus Ride fleet showcases how Velodyne’s intelligent lidar sensors are helping companies place autonomous vehicles on the road today,” said Mike Jellen, president and CCO, Velodyne Lidar. “Optimus Ride has an ingenious approach to providing people with access to efficient and convenient self-driving mobility—effectively solving the first- and last-mile problem.” (www.velodynelidar.com)

Power Transmission Engineering

Power Transmission Engineering's Statement of Ownership, Management and Circulation



Additional information about *Power Transmission Engineering* and its audience can be found in our 2020 media kit. Download it at www.powertransmission.com/adinfo.htm

UNITED STATES POSTAL SERVICE® Statement of Ownership, Management, and Circulation (Requester Publications Only)

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(1) Outside County Paid/Requested Mail Subscriptions stated on PS Form 3541 (include direct written request from recipient, telemarketing, and internet requests from recipient, paid subscriptions including nominal rate subscriptions, employer requests, advertiser's proof copies, and exchange copies.)	5,510	5,448
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e. Total Nonrequested Distribution (Sum of 15d (1), (2), (3) and (4))	8,508	8,608
f. Total Distribution (Sum of 15c and e)	14,269	14,278
g. Copies not Distributed (See Instructions to Publishers #4, (page #3))	300	300
h. Total (Sum of 15f and g)	14,569	14,578
i. Percent Paid and/or Requested Circulation (15c divided by 15f times 100)	40.4%	39.7%

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16. Electronic Copy Circulation

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b. Total Requested and Paid Print Copies (Line 15c) + Requested/Paid Electronic Copies (Line 16a)	8,833	8,676
c. Total Requested Copy Distribution (Line 15f) + Requested/Paid Electronic Copies (Line 16a)	17,341	17,284
d. Percent Paid and/or Requested Circulation (Both Print & Electronic Copies) (16b divided by 15f × 100)	50.9%	50.2%

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Power-Gen Alights on New Orleans

Alex Cannella, Associate Editor

One show we might not talk about enough is Power-Gen International, one of the biggest U.S. trade shows in the energy industry you can attend that will be going on November 19–21 in New Orleans. They've been running for over 30 years, see over 14,000 attendees, and cover wind, solar, natural gas, and just about everything in between. And, surprise surprise, a lot of products from ranging motors to drives fall under both Power-Gen's umbrella and our's.

As the showrunners themselves put it on their about page: "Our goal isn't to say we're the biggest and best event in power generation today. It's to be it—for our customers—for years to come."

Power-Gen's got all the classic hits for a trade show: a booth floor packed with over 900 exhibitors, a heaping pile of conferences sessions, designated "knowledge hubs" for long-form discussions of industry hot topics, and plenty of networking events.

The knowledge hubs primarily focus on grouping scheduled talks into specific energy industries such as natural gas and solar, but there are also a few stages dedicated to discussing specific fields of products such as IoT technology, the hot button topic that rears its head at pretty much every show in some capacity or another these days. One more track, "The Future of Conventional Power," will be looking into a crystal ball and trying to sort out what the future of some of these individual industries might be, as well as new problems that manufacturers in those fields will have to tackle.

Something perhaps a little unique that not every trade show has, however, is the Initiate! program that Power-Gen

will be running. The idea is to set up a small pavilion for eight up-and-coming start-ups in the industry chosen by a Power-Gen panel, and while the opportunity to apply has long since passed, it may well be worth checking out to see which eight companies ended up at the top of the pile.

The Initiate! program is, of course, just one corner of the trade show floor. There's plenty of other stuff worth taking a look at out there on the floor, too. Take WEG Electric, for example, a longtime exhibitor at the show, who have in the past shown off their alternator lines. Or Philadelphia Gear, one of the many companies under Timken's umbrella that specializes in gear design.

Also of particular note at the show will be Nidec's companies, Kato Engineering and Leroy Somer, as well as Flender, Ameridrives, and Ferry Capitain, all of whom service the energy sectors of the power transmission industry.

And there will be plenty more to explore and discover out on the floor, what with the other 900+ booths to go check out. If you're participating in the energy sector, Power-Gen's a solid show to take advantage of when it descends on New Orleans in mid-November. **PTE**

For more information:

Power-Gen International
Phone: (708) 486-0734
www.power-gen.com/index.html



November 6–8—AGMA Gear Failure Analysis (Fall) St. Louis, Missouri. Explore gear failure analysis in this hands-on seminar where students not only see slides of failed gears but can hold and examine those same field samples close up. Experience the use of a microscope and take your own contact pattern from field samples. Gear engineers, users, researchers, maintenance technicians, lubricant experts, and managers should consider attending. Instructors include Rod Budny (RBB Engineering) and Andy Milburn (Milburn Engineering, Inc.). For more information, visit www.agma.org.

November 19–21—Power-Gen International 2019 New Orleans, Louisiana. Power-Gen International provides comprehensive coverage of the trends, technologies and issues facing the generation sector. Displaying a wide variety of products and services, Power-Gen International represents a horizontal look at the industry with key emphasis on new solutions and innovations for the future. Topics include plant performance, cyber security, energy storage, flexible generation and more. Learn more at www.power-gen.com.

November 19–22—Formnext 2019 Frankfurt, Germany. Formnext is more than an exhibition and conference. It's an entire platform for companies from the world of additive manufacturing. Here, a veritable who's-who from the realms of design and product development, industrial tooling, production solutions, quality management, and measurement technology comes together with leading providers in basic materials and component construction. It will also explore clever ways in which AM can be integrated into process chains in industrial production. In addition, top international speakers and other experts will be on hand to engage conference attendees in in-depth discussions at the highest technical level. For additional information, visit formnext.mesago.com/events/en.html.

November 20–21—Automation Fair Chicago, Illinois. Automation Fair (Rockwell Automation) offers the latest technology on information solutions, innovations, smart devices, lifecycle services and more. Industry forums include automotive, chemical, food and beverage, life sciences, material handling, metals and mining, OEM, oil and gas and water/wastewater. The Automation Fair show floor will showcase over 150 interactive exhibits featuring the newest products, solutions and services. Attendees will experience the latest innovations firsthand and talk to solution experts from Rockwell Automation and members of the PartnerNetwork companies. Automation Fair offers more than 125 education and training sessions including hands-on labs, technical presentations and professional development hour credits. For more information, visit www.rockwellautomation.com.

November 26–28—SPS – Smart Production Solutions Nuremberg, Germany. The exhibition, featuring 1,650 automation technology providers, will showcase current products and solutions in industrial automation as well as trend-setting technologies of the future. Exhibition visitors will benefit from the wide range of products and services offered by national and international automation and digitalization providers, and within one day will still be able to gain a complete over-

view of the market. Digitization is having a major impact on the automation industry. Topics such as big data, cloud technology, 5G and artificial intelligence are often presented jointly with automation providers on the basis of practical examples and demos. In addition, topic-related showcases and presentations at the exhibition forums help to illustrate digital transformation in the manufacturing industry. For more information, visit sps-exhibition.com.

December 3–5—AGMA Epicyclic Gear Systems: Application, Design and Analysis Seattle, Washington. Learn and define the concept of epicyclic gearing including some basic history and the differences among simple planetary gear systems, compound planetary gear systems and star drive gear systems. Cover concepts on the arrangement of the individual components including the carrier, sun, planet, ring and star gears and the rigid requirements for the system to perform properly. Critical factors such as load sharing among the planet or star gears, sequential loading, equal planet/star spacing, relations among the numbers of teeth on each element, calculation of the maximum and optimum number of planet/star gears for a specific system will be covered. This session provides an in-depth discussion of the methodology by which noise and vibration may be optimized for such systems and load sharing guidelines for planet load sharing. The instructor is Raymond Drago and Steve Cymbala. For more information, visit www.agma.org.

December 9–12—CTI Symposium Germany 2019 Berlin, Germany. CTI Symposium Germany provides the latest automotive transmission and drive engineering for passenger cars and commercial vehicles. The international industry event delivers the appropriate platform to find new partners for purchase and sales of whole systems and components. Automobile manufacturers, transmission and component companies give an overview and outlook on technical and market trends including digital manufacturing, IoT, zero-emissions, electric vehicles, hybrid transmissions and more. Speakers include representatives from Porsche, Volkswagen, StreetScooter, Continental, BorgWarner, Magna Powertrain and more. For more information, visit drivetrain-symposium.world/.

January 6–10—Sci-Tech 2020 Orlando, Florida. From its creation in 1963, the American Institute of Aeronautics and Astronautics (AIAA) has organized conferences to serve the aerospace profession as part of its core mission. Spanning over 70 technical discipline areas, AIAA's conferences provide scientists, engineers, and technologists the opportunity to present and disseminate their work in structured technical paper and poster sessions, learn about new technologies and advances from other presenters, further their professional development, and expand their professional networks that furthers their work. Five focus areas include science and technology, aviation, space, propulsion and energy/defense. For more information, visit scitech.aiaa.org/.

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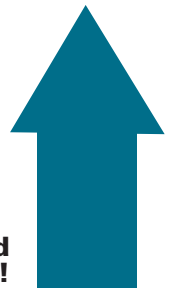
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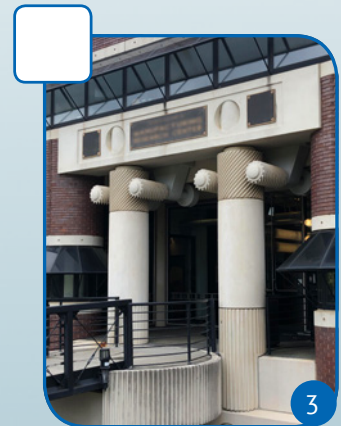
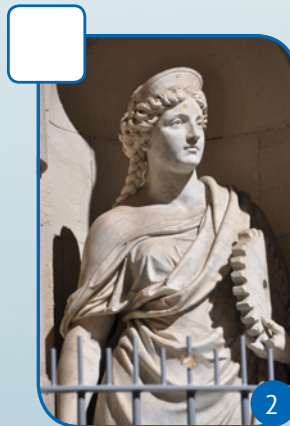
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Geography Quiz

How well do you know your public gear art? Match wits with the Power Play travel team by trying to identify the locations of these awesome works of public art. Answers at the bottom of the page!

- A. Sculpture on the façade of “El Borsi,” Barcelona, Spain.** This allegory of Industry was sculpted in 1888 by Joan Roig i Solé (photo by Josep Bracons, cc-by-sa-2.0).
- B. Central Electro Chemical Research Institute, Tamil Nadu, India.** The Central Electro Chemical Research Institute is one of a chain of forty national laboratories under the aegis of the Council of Scientific and Industrial Research in New Delhi. Founded on 25 July 1948 at Karaikudi in Tamil Nadu, CECRI came into existence on the January 1953 (photo by Balajijagadesh, CC-BY-SA-3.0).
- C. Miyazaki Shrine, Miyazaki, Japan.** Dedicated to Emperor Jimmu, the mythical first emperor of Japan, the shrine is said to have been established over 2600 years ago (photo by Soramimi, CC-BY-SA-4.0).
- D. The Fuller E. Callaway Jr. Manufacturing Research Center, Atlanta Georgia.** This building at Georgia Institute of Technology features an obvious gear motif.
- E. Dirksen Senate Office Building, Washington, DC.** 51 different sculptures appear between the windows of the Dirksen Senate Office Building, featuring the subjects of shipping, farming, manufacturing, mining and lumbering (photo by Jim Kuhn, CC-BY-2.0).
- F. The Mercator Fountain in Duisburg, Germany** celebrates the life of Gerardus Mercator, 16th-century cartographer and creator of the “Mercator Projection.” The sculpture features four sculptures at its base, representing shipping, science, trade and commerce. Created by the Düsseldorf sculptor Josef Anton Reiss and unveiled in 1878 (photo CC-BY-3.0). **PTE**



ANSWERS: 1) E, 2) A, 3) D, 4) C, 5) F, 6) B

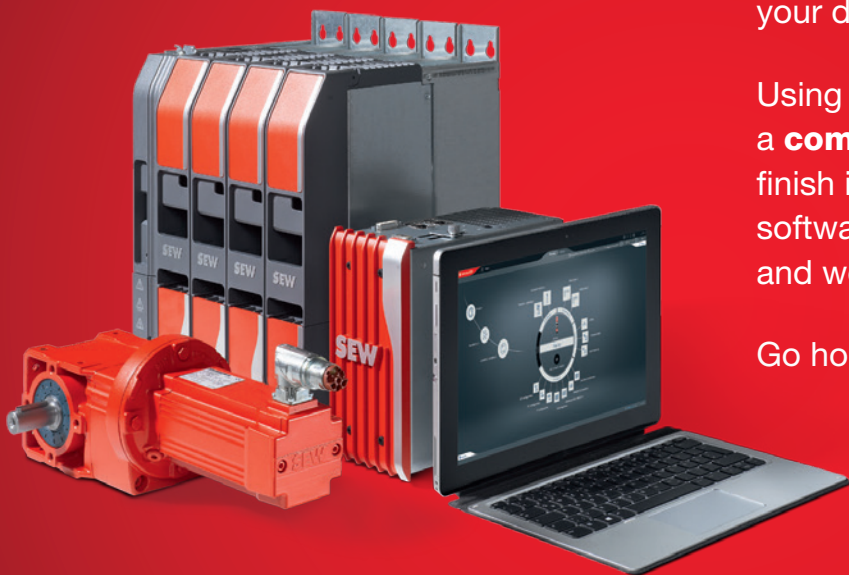


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